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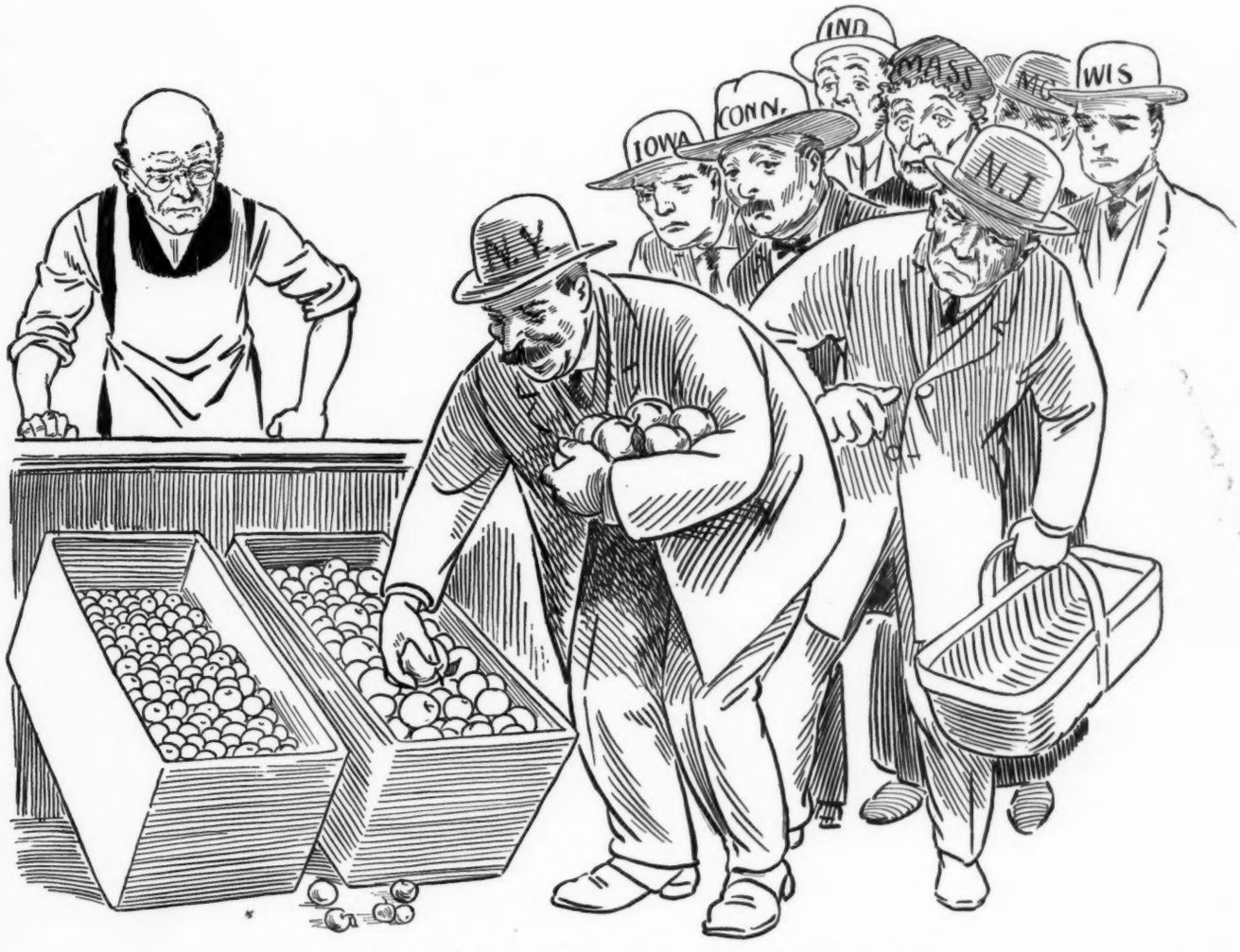
POWER

Vol. 39 NEW YORK, APRIL 7, 1914 No. 14

The Prudent Buyer



LOOK! HE'S PICKING OUT THE BEST ONES

IF these individuals went marketing for apples and were compelled to line up, each allowed to select the best ones, how bitterly those in the rear would complain.

But when they go market ng for coal!

Those who specify what they want get what they want, and pay for what they get. Those who don't are at the tail end of the line. They take what they get, but by no means always get what they pay for.

New York City saved over $200,000 on its coal bill the first year it bought by specification and slightly changed boiler room methods. By doing the same thing, New York State expects to save over $250,000 a year.

Who's next?

605 P54
v.39, pt.2

Powdered Coal in Boiler Furnaces

By William A. Evans

SYNOPSIS—Describes the results of numerous experiments in developing a boiler to successfully burn powdered coal, and tells why some methods of pulverized-fuel burning have failed. A checker-work wall, placed near the coal inlet to promote quick ignition, clogged with slag and quickly melted away. One experiment showed that the fuel and air absorbed more heat from the firebrick at the point of ignition than the walls could supply. To avoid this, the flame is caused to reverberate back on itself. Nearly all kinds of firebrick lining were tried with a total destruction of each within two hours.

Experiments on Three Continents

The essential features of a powdered-fuel-burning furnace are suggested by a study of the many attempts made in comparison with a few successful installations. The experience of the designers of the Bettington boiler, especially adapted to powdered fuel, has been the experience of all up to the point of final failure. The developers of this boiler may be credited with carrying their experiment to a logical conclusion, whether this boiler is the

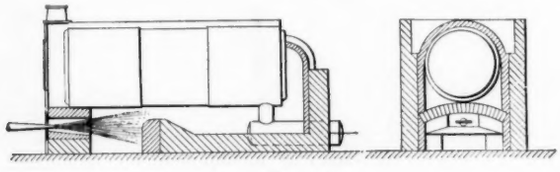


Fig. 1

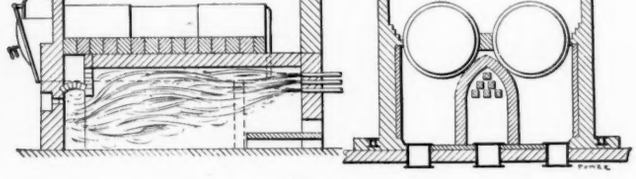


Fig. 2

Figs. 1 and 2. Old Ways of Feeding Powdered Coal to Tubular Boilers

only solution or whether it ever comes into common use.

The experiments were started over ten years ago, and have been conducted successively on three continents. They began in South Africa with a series of trials involving ten different settings on return-tubular and water-tube boilers. Four of these are shown in Figs. 1, 2, 3 and 4. The other six were but slightly different and showed practically the same results. The experiments were followed by others made by the same engineers with an installation (Fig. 5) at a central station in New York City. These experiments led directly to the design and building of the boiler shown in Fig. 6.

Point of Ignition Shifts

Fig. 1 shows the simplest arrangement under a return-tubular boiler. The grates are removed and the fuel is blown in through a flat rectangular tuyere. After ignition with an oil-soaked waste torch, the point of ignition gradually traveled forward away from the hot firebrick lining to a point where the flame was soon stifled by the cooling effect of the boiler surface. Instead of storing heat in the firebricks surrounding the fire, the blast of coal and air absorbed what little accumulated there during the starting period, and there was nothing to produce the initial ignition temperature for the incoming fuel. This action was accompanied by large deposits of dust and unburned coal in the tubes and under the boiler. During the short time when the flame was maintained, slag accumulated around the tuyere.

Influence of Flame on Slag

To provide greater radiating surface and larger settling space for the deposit of ash, two boilers were then arranged as in Fig. 2. Difficulties were again experienced in maintaining the flame and preventing the deposit of dust in the tubes. The flame seemed to blow itself out. Attempts were made with this setting to store the heat and obtain a regenerative effect by building a checker-work wall a few feet from the tuyere. This added another trouble as the slag clogged the checker-work wall; the wall frequently burned down. Enough heat was developed with this setting to show that slag would form wherever the flame reached and that provision must be made for its disposition. This was attempted in future trials by sloping the bottom of the furnace toward traps through which the slag was supposed to drain.

Air for Combustion Is Preheated

On account of the continued presence of dust in the tubes of the return-tubular boiler, it was decided to experiment with a water-tube boiler, from the tubes of which the dust could easily fall and settle. The setting, shown in Fig. 3, was arranged with long travel for the flame. Fuel was supposed to shower through the openings *A* and air to rise preheated between the inner and outer walls and mix with the falling powdered fuel. It was claimed that the fuel and air were not thoroughly mixed before entering the furnace, and, further, if combustion had been possible, heat would have caused the coal to coke in the passages *A* and the escaping coal tar would have clogged them completely.

Reverberating Flame Deemed Necessary

At this point the experimenters were convinced that the combustion of explosive mixtures in motion requires some igniting medium other than the radiation of heat from the brickwork alone. It was stated that the traveling fuel and air absorb more heat from the firebrick at the ignition than the flame is able to give in return. The result is that the brick at the point of ignition is continually cooling and gradually forcing the ignition forward into a hotter zone in the brickwork. This would seem to call for an auxiliary flame, always fixed close to the end of the fuel pipe or tuyere. It was provided for by making the flame reverberate back upon itself in its passage to the boiler, as in Fig. 4.

The Boiler a Low-Temperature Furnace

Good ignition was obtained in other furnaces with a direct flame and with no auxiliary igniting medium. Nevertheless, the rapid absorption of heat by boilers lends

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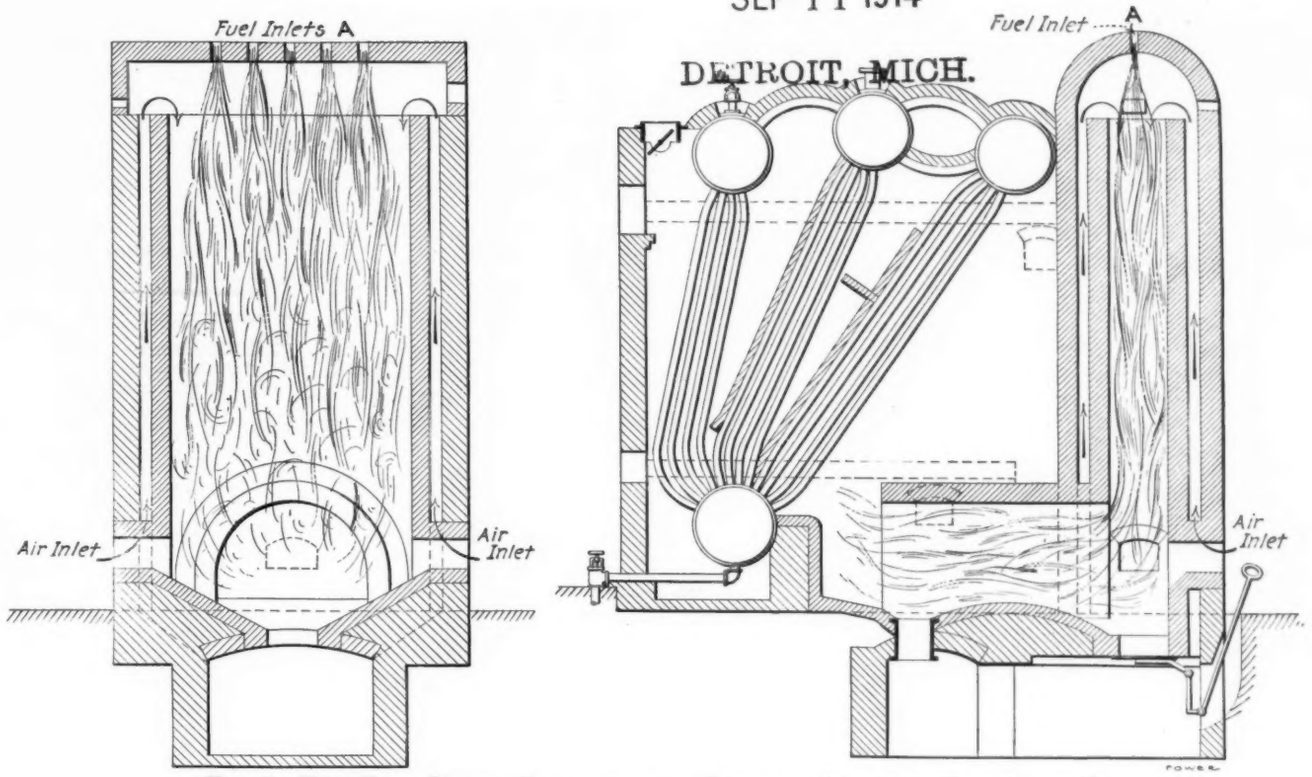


FIG. 3. THE FUEL INLETS PLUGGED WITH TAR AND COKE AND THIS PLAN FAILED

credence in this (first) practice, especially on boilers of low capacity, where only moderate heat is maintained in the combustion chamber. The boiler under ordinary ratings is a low-temperature furnace and powdered coal requires high temperature throughout for ignition and complete combustion. It is likely that trouble in maintaining ignition in such a furnace as Fig. 2 was due to coarse coal or an insufficient mixture of coal and air, either of which would be materially overcome by the reverberating flame. The arrangement, Fig. 4, was pronounced a success after trials of several different qualities of brick were tried. Magnesite lining stood up well, the flame was maintained, and combustion was complete. Slag formed on the sides of the vertical combustion chamber, trickled down the sides and then dropped and cooled in small lumps below the tuyere.

FIREBRICK DESTROYED IN TWO HOURS

It was probably a success under moderate boiler ratings, but when applied to boilers subjected to heavy overloads, such as prevail in central stations and in other practice, no brick could stand the intense heat. Fig. 5 shows the

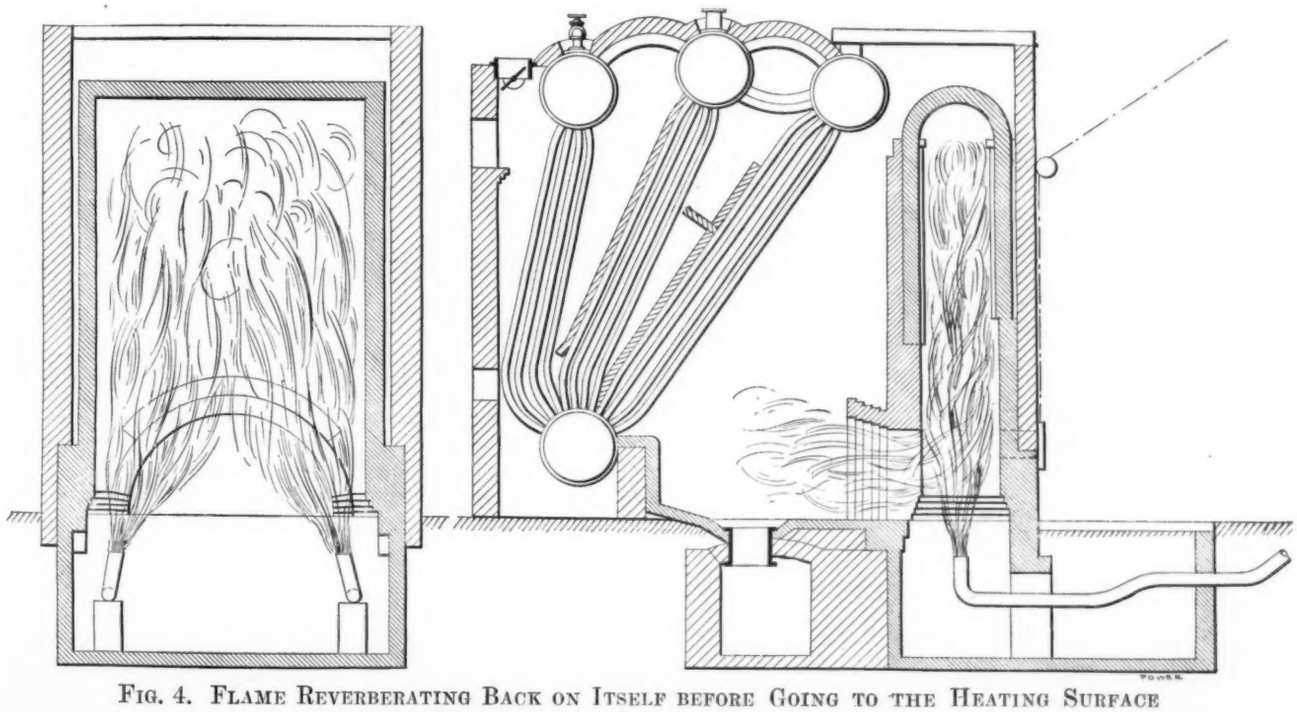


FIG. 4. FLAME REVERBERATING BACK ON ITSELF BEFORE GOING TO THE HEATING SURFACE

method of burning as applied to a water-tube boiler in the station mentioned above. Every conceivable quality and mixture of brick lining was tried. Nearly all were burned to destruction within two hours. Once it was possible to make a run of six hours by careful tempering of the flame and running the boiler at about rated capacity; even then the brickwork tumbled in. The boiler showed a fair evaporation though much unburned coal was found under the back end. A hard, glassy coating formed on the lower tubes next to the flames. This was probably due to the sticky nature of the hot ash together with the coal-tar products escaping and only partly burning on striking the tubes.

Part of Setting Is Water Cooled

The final step was to cool the brick lining of the combustion chamber. This was accomplished by using special bricks through which passed water tubes connected into the path of the boiler circulation. This feature was incorporated in the special boiler, Fig. 6, known as the Bettington. In it the fuel enters the furnace vertically and upward through a water-cooled tuyere and is ignited by the flame reverberating back upon itself. The hot gases pass up around the water tubes in the annular space

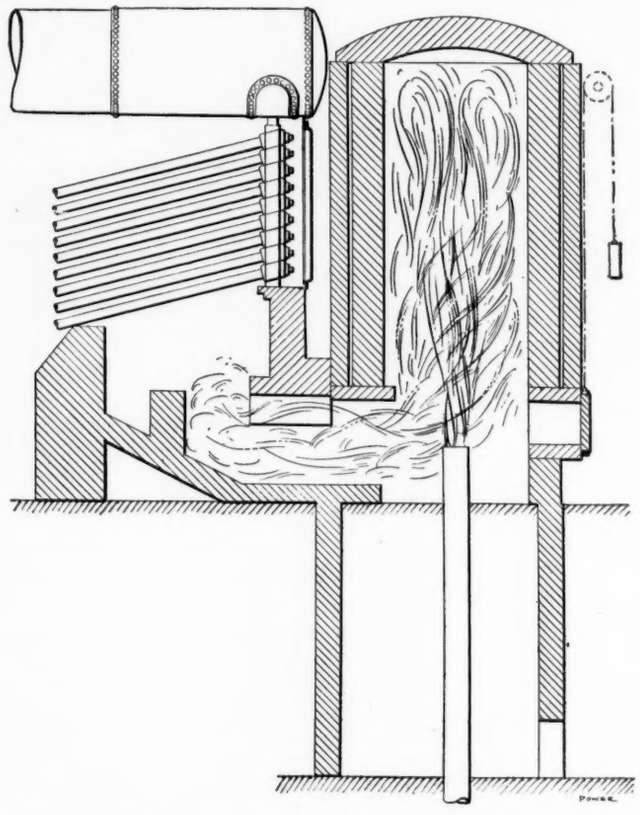


Fig. 5. Powdered-Coal Furnace as Applied to B. & W. Boiler in New York Station

between the combustion chamber and the outside wall of the boiler. Even with this method of cooling, the brickwork melts away at the hottest part of the flame, leaving only a thickness of ¼ to ⅜ in. protecting the tubes. The whole inside or fire surface of the brick fuses into a solid mass. It will be noted that in the specially designed boiler there are no places for the deposit of ash within the influence of the flame. This does away with the possibility of the fusing of the ash by the heat, on or in places where it should not remain and from which it would be difficult to remove it.

Handling of Slag a Problem

It was found that the sloping floors of the furnace did not ameliorate the slag difficulty. The slag would not flow and to get it out after cooling involved considerable labor and the destruction of the brickwork. In the Bettington boiler the only place where ash can settle is directly below the combustion chamber. Here the ash is

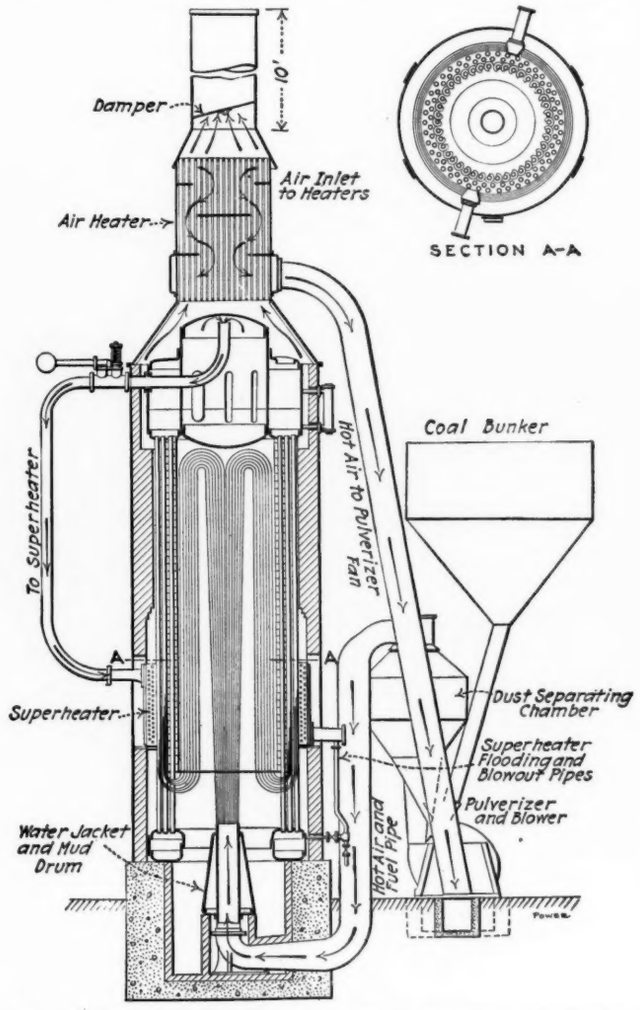


Fig. 6. The Bettington Boiler, Designed for Burning Powdered Coal

not in contact with the flame, and is at a temperature low enough to prevent the separate drops of slag from sticking to one another.

The boiler is reported to be a success; that is, it "stands up" well and has few of the operating difficulties that have prevented others from even approaching the economies in fuel and operating cost that have been so definitely demonstrated possible with powdered coal in other types of industrial furnaces. It has shown a thermal efficiency of 80 per cent. on very poor coal and several thousand horsepower is now operating. The 80 per cent. efficiency with 4 per cent. deduction for power for pulverizing is not so remarkable, but the boiler gives one solution of the problem of combustion of powdered coal and its design is possible of improvement that may make the thermal efficiency more attractive.

Vacuum Ash-Removal System

A simple system for the removal of ashes which has been in successful operation in a number of plants is shown in the accompanying illustration. As manufactured by the Girtanner Daviess Engineering Co., of St. Louis, Mo., the system is made up of 6- or 8-in. chill cast-iron pipe of suitable lengths and 1 in. thick. The pipe is joined by tongue-and-groove cast flanges which are fitted with a special packing and bolted to make an air-tight joint. When it is necessary to make a turn an elbow of 4-ft. radius or greater is used. The elbow is made up in sections about 18 in. long. These sections are split, and the outer piece, which takes up nearly one-half of the circumference of the pipe, is made extra heavy to resist the wear at this point. At the center it is 2 in. thick. As indicated in the illustration the two parts are bolted together, so that the outer piece may be easily renewed.

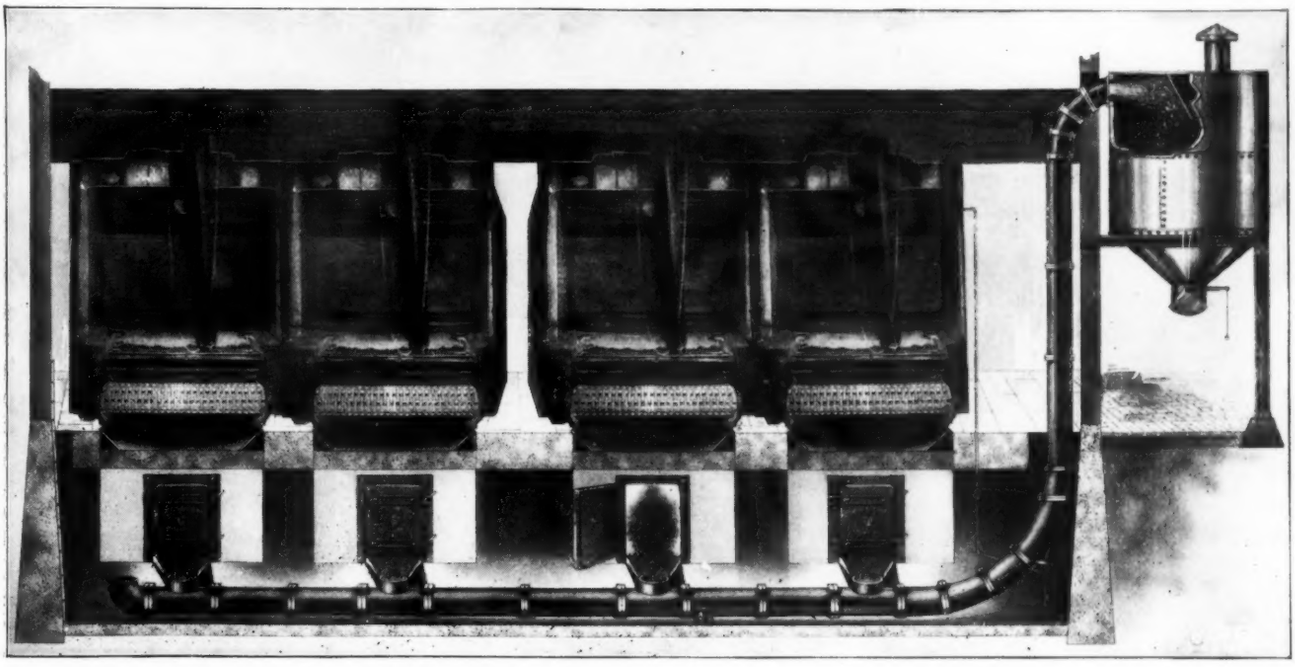
Hoppers for receiving the ashes are located at points opposite the ashpits of the boilers. The opening in the hopper is round and tapers toward the bottom to insure a tight-fitting lid. The bottom of the lid conforms to the diameter of the pipe so that when it is set in position there is no interference with the flow of air and ashes.

The ashes are moved through the conveyor by steam from a nozzle pointing in the direction of flow. The nozzle is located between the last hopper and the point of delivery, and is either ½ or ⅝ in. in diameter, depending on the distance and amount of ashes to be removed. Turning on the steam creates a vacuum of 16 to 25 oz. and induces a flow of air through the pipe. The ashes are fed into this stream of air at the rate of about 200 lb. per min. and may be discharged into a car, an ash bunker or wherever desired. In one of the installations now working, ashes are being conveyed over 300 ft. and in another elevated 97 ft.

The cost for steam is the principal operating expense. In a recent test on a system using an 8-in. pipe and a ⅝-in. nozzle, to which boiler pressure of 110 lb. gage was supplied, 1850 lb. of steam per hour was required to handle seven tons of ashes. At 20c. per 1000 lb. for steam, the cost of removal per ton of ash would amount to

$$\frac{1.85 \times 20}{7} = 5.29c.$$

With the ½-in. nozzle less steam would be required but the capacity would be less, so that the cost would be about the same as for the larger nozzle. Raising the pressure in either case would increase the volume of steam discharged and also the capacity of the system, so that it is fair to assume an average charge of 5 to 6c. per ton of ash.



Application of Vacuum Ash-Handling System to a Battery of Boilers

Rapid Chimney Building—A St. Louis construction firm recently built a chimney 85 ft. high and 3 ft. inside diameter, in seven working days. It was of reinforced-tile concrete, with a reinforced-concrete foundation, and was put in service 16 days after the receipt of the order. During its construction the heaviest snowfall in ten years occurred. At no time was it warmer than 20 deg. F., when work was started in the morning. The sand was heated before mixing and the tile was heated before placing. Fires were kept in the chimney constantly with all openings closed.

A Big Coal Bill—The Commonwealth Edison Co. burns about 5000 tons of coal daily and its coal bill is about $2,000,000 a year. About 250,000 tons is kept in reserve in or near Chicago at all times. Nearly all of this is of egg or lump size, as the danger of fire from spontaneous combustion is less with the larger sizes. Thermometers are placed in all coal piles and weekly records of temperatures are taken. It is frequently found necessary to move piles of screenings of mine-run coal to prevent or fight fires.

Calibration of Indicator Springs

By S. K. Baldwin

SYNOPSIS—Full instructions for testing inside and outside springs and an accurate method of locating the atmospheric line.

Indicator results are supposed to be correct to within 2 to 5 per cent., but as the spring is often as much as 2 per cent. out, this is an error right at the start which may make a further discrepancy. It seems almost needless to say that the link work of an indicator must be in good shape, yet little attention is paid to this point. Some indicators have so many links and loose joints that there is a sixteenth-inch pencil movement before the spring is moved. And again, so little care is taken of the piston that perfectly absurd results are obtained, such as the intake line of a gas engine or compressor above the atmospheric line. At pressures close to atmosphere the indicator spring is practically in equilibrium, and a small friction force will hold the pencil quite far away from the position corresponding to the pressure. This same friction near the equilibrium point will displace the atmospheric line, especially with a "soft" spring, and this is most important in both gas engine and air cylinders.

To obviate this piston friction, it is necessary to have the parts in such good adjustment that, while looseness is all but eliminated, the piston and its rod will drop down through the indicator cylinder by gravity, the spring having been removed. After this trial, connect up the link work, but without the spring, and ascertain whether or not gravity will cause the entire system to drop. Any sticking during the stroke will show up and the cause should be removed.

The next test is to close the bottom of the indicator cylinder with the finger and if there is proper piston tightness, this closure should prevent the piston from dropping because of the air trapped inside. Removal of the finger and escape of the air should allow the piston to drop at once by its own weight.

With the indicator in first-class condition, the next step is to calibrate the spring by subjecting the indicator to a series of constant pressures whose values are exactly known, and to rotate the indicator drum so as to draw horizontal lines on the paper corresponding to these pressures. The heights of these lines are measured from the atmospheric line, and then the scale is determined by dividing the true pressure by this height. For instance, suppose the pressure is 120 lb. per sq.in., and the line drawn is exactly 1.5 in. above the atmospheric line, then the scale of the spring is

$$120 \div 1.5 = 80 \textit{ lb. per in.}$$

of vertical movement. If the height above the atmospheric line had been 1.51 in., the scale of the spring would be

$$120 \div 1.51 = 79.5 \textit{ lb. per in.}$$

This would introduce an error of about 0.6 of 1 per cent. in the calculation, if the maker's stamping of 80 lb. had been assumed to be correct. There are, no doubt other factors of a test more incorrect than this, but if such an error can be at once eliminated by proper calibration, it should by all means, be done. It should be remembered that such errors may accumulate, instead of neutralizing one another, and thus affect the final test result to a far greater extent.

There are various ways of applying the known pressures to the indicator. One way is to use air or steam, controlled preferably by a needle valve, and providing an adjustable leak in the system for the escape of the air or steam. This leak is essential as otherwise it will be found impossible to control the pressure. Of course, the applied pressures must be known, and a way to do this is to use a good pressure gage which has been carefully calibrated by a deadweight tester. A curve is plotted, showing the exact reading of the gage for every known pressure within its range. From this curve the true pressure exerted for any gage reading may be read and applied to the corresponding line on the calibration diagram drawn by the indicator.

As practically none but the most expensive test gages will read exactly alike in both directions of travel, this limits the usefulness of steam or air calibration to those cases where it is absolutely necessary. The method is long drawn out and involves the calibration of the gage and the drawing of its curve before applying the true pressures to the indicator lines.

When an inside-spring indicator is used, this method allows a spring temperature during the test, which will be approximately that under which the spring will be used. Inside spring indicators are almost invariably much stiffer cold than hot, so that the scale will be different.

As most modern indicators are of the outside-spring type, the process of calibration is simplified. I have found the use of the deadweight tester, with oil, to be the handiest and by far the most accurate method. Of course, the indicator piston must be reasonably tight, or excessive oil leakage will give trouble. Some form of pump for supplying more oil to replace the inevitable piston leakage should be provided. At best, it is a rather unpleasant job, as the operator is likely to become pretty well oiled during the process.

One objection to the use of oil is that it takes an appreciable time for the indicator piston to come to its corresponding point. It is imperative that the work be done slowly, allowing plenty of time for all parts to come to equilibrium for each pressure. The deadweight plunger should, of course, be rotated during this time, and the indicator gently rapped with a piece of wood to assist in neutralizing the friction. More uniform and consistent results are obtained if the full pressure is gradually applied to the indicator and then gradually removed again before starting to draw any lines. This lubricates the piston and gets all parts into working condition.

As intimated before, the great trouble in all these calibration methods is to locate the atmospheric line. It is impossible to do it when the indicator is full of oil. A trial will show a displacement of $\frac{1}{32}$ to $\frac{1}{16}$ in., depending upon the stiffness of the spring. This is because the oil is too viscous and allows no air leaks, and with the spring under no tension at all, as at atmos-

pheric pressure, only a small friction force will displace it materially. For this reason, it is good practice, first to give the preliminary loading, then to remove it and take the indicator from its connections, allowing all the oil to run out of the cylinder from both below and above the piston. Then tap the indicator with a piece of wood, keeping it in the hand right side up; finally draw the atmospheric line with the indicator still in the hand and perfectly free from all restraint. Then attach the indicator to the deadweight tester, apply the load in at least five steps and draw a line for each step, observing the precautions of time allowance and vibration, being also careful not to touch any of the link work with anything.

With such care as this I have repeatedly obtained lines which were identically located for both increasing and decreasing pressures. Always increase the pressures in steps to the maximum and then decrease them in the same steps, and if the corresponding lines vary 0.02 in. for any one pressure, discard the test. A less variation than this may be allowed to stand and the average position be taken for the true one.

All this precaution may seem excessive, but unless the calibration is made properly it would be better to take the maker's stamping as correct, for it will be nearer the truth than a so called "rough calibration."

It is customary in working up one of these spring-calibration diagrams to measure all heights from the atmospheric line. From this very fact, it is obvious that the location of this line is by far the most important operation. If the pressure lines vary a little, an average will give the truth, but if the atmospheric line varies, every result of all the different pressures is wrong and no average will make it right.

It is easy to tell a displaced atmospheric line, because it will give a scale which either increases or decreases as the spring is compressed. If the atmospheric line is correctly located, the scale of the spring will be found practically constant throughout its range. To eliminate the difficult process of properly locating the atmospheric line, the writer has adopted the method of measuring all the distances from line to line, and taking the average of these. It is not at all practical to base calculations on distances of less than ½ in., because the slightest error of measurement is such a large proportion of the whole distance that relatively large errors can be introduced. My procedure is to measure from each pressure line to every other pressure line, neglecting all spacings of less than ½ in. In this way, scale calculations of great consistency for the entire range of a spring have been obtained. All dependence upon the erratic atmospheric line is removed with its attendant errors.

To illustrate, Fig. 1 shows a calibration diagram for a 60-lb. spring and Fig. 2 for a 200-lb. spring. These diagrams have been divided off into lettered sections, each section corresponding to measurements from some one pressure line as a base. For instance, in Fig. 1, section *A* shows measurements to all pressures from atmosphere; section *B* from the 25-lb. line, etc. Distances less than ½ in. have not been included in the averages. In section *A*, where all measurements are from what was obtained as the atmospheric line, the spring scale appears to decrease as the pressure increases. From atmosphere to 40 lb., the measured distance is 0.65 in., giving a scale of

$$40 \div 0.65 = 61.6 \textit{ lb. per in.}$$

From atmosphere to 55 lb., the scale is 60.8, and so on to 110 lb., where the scale appears to be reduced to 60 lb. The 25-lb. line has been neglected, because it is less than ½ in. from the atmospheric line, but calculation from its actual measurement runs the scale up to 62.5 lb. at this point. An average of all the calculated scales measured from atmosphere, with the exception of the 25-lb. line, gives an apparent scale of 60.6 lb. per in.

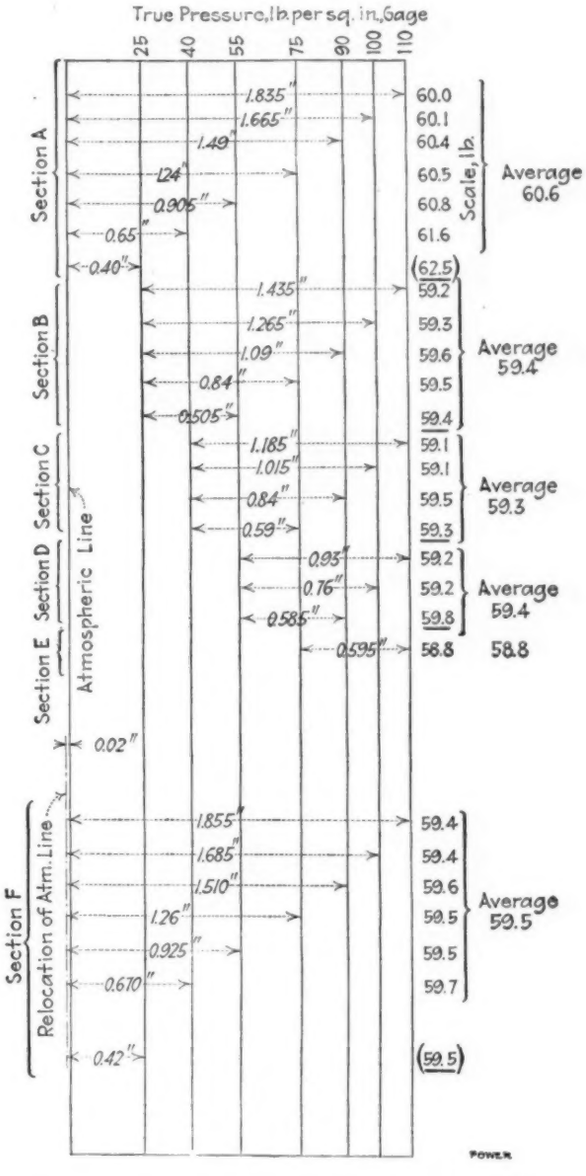


FIG. 1. CALIBRATION DIAGRAM FOR A 60-LB. INDICATOR SPRING

Measuring from the other lines gives scales whose averages are: Section *B*, from 25-lb. line, 59.4 lb.; section *C*, from 40-lb. line, 59.4 lb.; section *E*, from 75-lb. line, 58.8 lb. It will be noticed that in each section, measuring from any one pressure line (except section *A* from atmosphere) there is no apparent increase or decrease of scale. The average of sections *B*, *C*, *D* and *E* is 59.3 lb. per in. This is a total average of all values;

not an average of averages, as this last would give equal prominence to section *E*, with only one figure; whereas it should have a relative weight of one-thirteenth of the entire thirteen numbers.

In section *F*, Fig. 1, the atmospheric line has been moved 0.02 in. downward, assuming that the sticking of the indicator piston when the spring was thus practically free of compression, resulted in this much displacement of the pencil. This is well within practical probabilities. Moving the atmospheric line down this distance results in adding 0.02 in. to each of the measurements in section *A*, these now being as in section *F*. Calculation from these new measurements from the relocated atmospheric line gives a scale whose average value is 59.5, and which shows practically a constant value throughout the range. Even the 25-lb. line gives this same value for this relocated atmospheric line. Also, the average value of section *F* is in almost perfect accord with sections *B, C, D* and *E*.

It may well be assumed that in this case the atmospheric line was misplaced 0.02 in. by sticking, and the average scale obtained from measurements from all sections, except section *A*, is practically 59.4 lb. per in. This again is an average of all 19 numbers, thus giving equal weight to each separate measurement. Comparing this value of the most probable scale of this spring with that which would be obtained from an average of section A, from the original atmospheric line, or 60.6, it will be found that 60.6 is just 2 per cent. greater than 59.4. Thus it is plain that a 0.02-in. misplacement of the atmospheric line in calibration renders the scale and all horsepower results based on that scale, wrong from the very beginning by 2 per cent. In this case it would have produced an error of only 1 per cent., or half the error, if the experiment had assumed the maker's marking to be correct at 60 lb. It must be remembered that these errors of the indicator spring are carried on to the figures for steam consumption per indicated horsepower-hour, mechanical efficiency and any other determinations based on the indicated horsepower.

In Fig. 2, is shown a calibration diagram for a spring marked 200 lb. per in. Section *A* shows measurements from the atmospheric line, resulting in an average scale of 196.4, the scale appearing to increase rapidly with the pressure, with the single exception of the distance measured to the 250-lb. line. The other sections show measurements from the various other pressure lines, neglecting, as before, all distances less than ½ in. Some of these shorter distances are given in brackets, although not included in the averages. The total average of all the seven values over half inch, of sections *B, C* and *D* is 199.1 per in., which is 2.7 lb. greater than the apparent scale shown by measurement from the atmospheric line.

It was next ascertained if a relocation of the atmospheric line would help, and a new position 0.01 in. above the original line was selected, as shown in section *E*. The distances measured in section *E* are all 0.01 in. shorter than those in section *A*, and the resulting average scale in section *E*, which is remarkably uniform, is 198.6 lb. per in. Taking an average of all the thirteen separate values in sections *B, C, D* and *E* gives a final average of 198.9 lb. per in., which probably is nearest the truth. This is only 1.1 less that the maker's marking instead of 3.6 lb. less. The apparent correction by atmospheric line measurement would have been about 1¾ per cent., whereas the more probably true correction is one of only about ½ of 1 per cent. Again, in this case, the maker's marking was nearer the truth than an erroneous, although really carefully made calibration. All this is due to a misplacement of the atmospheric line of only 0.01 in.

No doubt the objection will be raised that it is impossible to make such close measurements of pencil lines drawn by an indicator. Judging from many of the wide lined and "smudgy" indicator diagrams the objection is well taken. However, such accurate work as this requires a certain amount of skill, a sharp pencil point and a light pencil pressure.

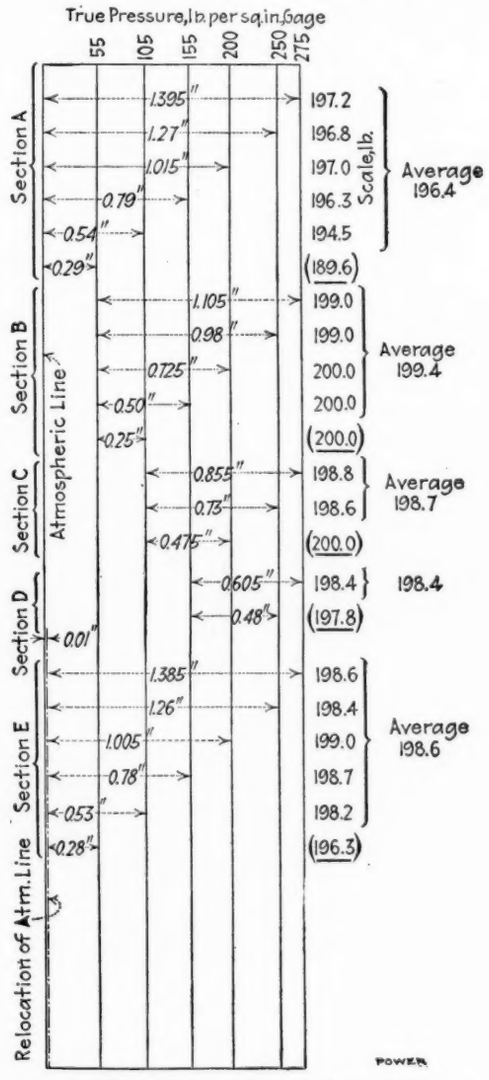


FIG. 2. DIAGRAM FOR A 200-LB. SPRING

This error is quite comparable to those of cord stretch and drum inertia which have recently been given considerable attention. It is perfectly possible, with a scale of 50 per in. to read to the nearest half hundredth, or 0.005 in. Of course, this requires estimation to ¼ of a division, but a little skill makes this easy. If preferred, a 100 scale may be used, reading to half a division, but a magnifying glass would be required, so that the 50 scale is easier to handle. No attempt is made to measure closer than the nearest half hundredth of an inch, or 0.005 in., as anything closer than this is out of the question, both as to possibility and necessity.

Multi-Stage "Economy" Steam Turbine

The steam turbines of multi-pressure type, Fig. 1, built by the Kerr Turbine Co., Wellsville, N. Y., are rated from 700 to 1800 hp. Turbines of smaller capacities up to 700 hp. were built by the company before the larger sizes were developed. These earlier designs embodied buckets of the Pelton type, which could not be developed to desired efficiencies. These buckets were, therefore, supplanted by vanes and blades, Fig. 2, producing parallel flow of steam in the direction of the turbine shaft and capable of better water rates.

Figs. 3 and 4 show the horizontally split shell employed in the larger machines, and how the rotor may be inspected or removed without breaking the steam connections. When the turbine cover is removed, each wheel is exposed down to the carbon packing on the shaft, there being no diaphragms left between the stages, as these are integral with the casing and lift off with it. The guide vanes or steam nozzles are cast in the diaphragms. Fig. 5 shows a section through a turbine of 500-750 kw. capacity.

Steam is expanded in a number of stages or steps, and the pressure drop at each set of nozzles is comparatively small, with correspondingly low steam velocity, the latter, it is said, rarely over 1000 ft. per min. The leakage area from stage to stage is also small, being confined to the annular space where the shaft goes through the pressure chamber walls or diaphragms.

Leakage from stage to stage at the shaft is prevented by floating carbon packing rings, held in the diaphragms and in the high- and low-pressure ends with cover plates, which are so arranged that they can move in any direction, in case the turbine shaft should vibrate with a large dose of water. The steam pressure, being higher on one side of the diaphragm than on the other, keeps the carbon rings tight against ground seats.

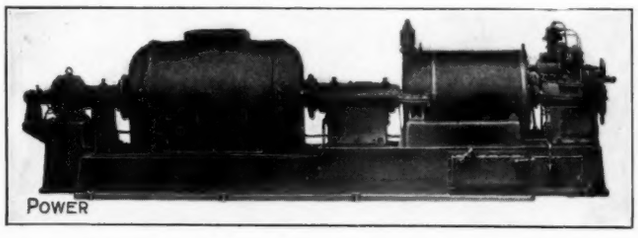


FIG. 1. KERR MULTI-PRESSURE TURBINE

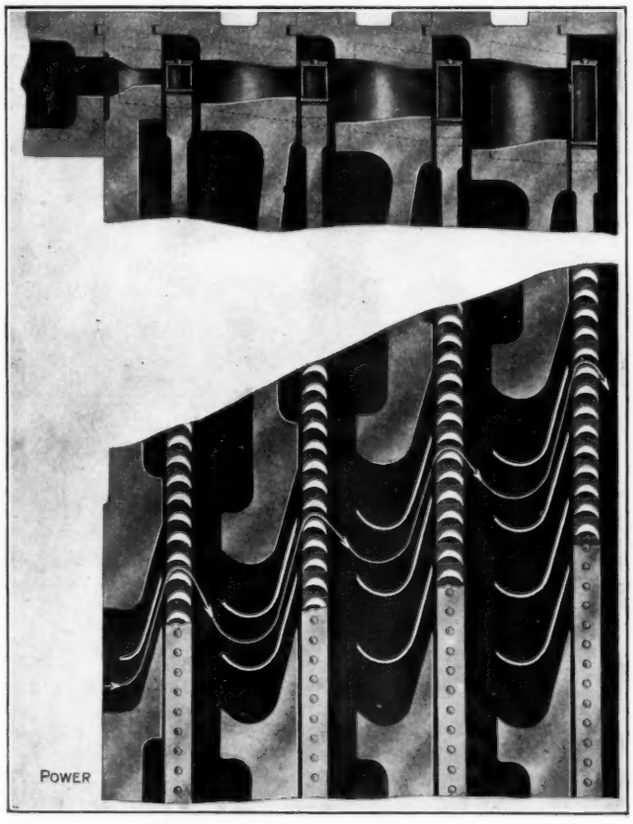


FIG. 2. SHOWING OPERATING PRINCIPLE OF THE TURBINE

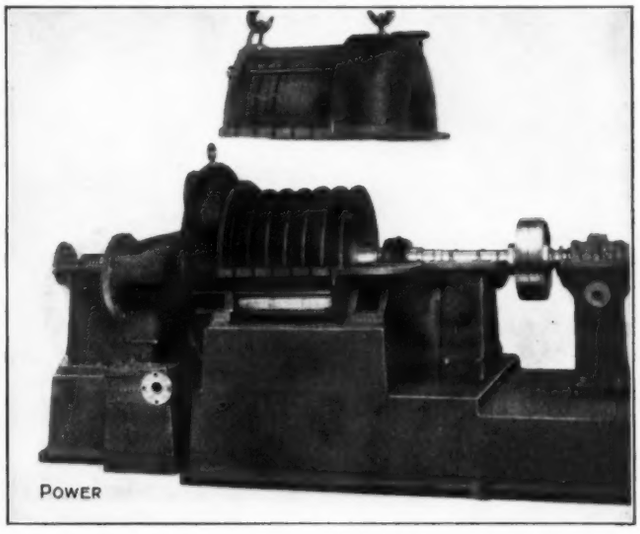


FIG. 3. SHOWING HORIZONTALLY SPLIT CASING AND PEDESTAL BEARINGS

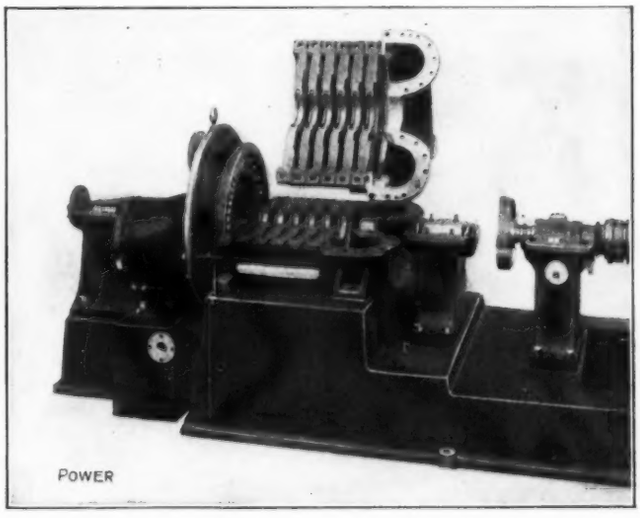


FIG. 4. TURBINE WITH ROTOR REMOVED

The large clearance permissible at the buckets is utilized, as shown in Fig. 6, to protect the buckets from stripping, and the hard, tough original skin left on the drop-forged buckets resists the minimized tendency toward erosion. The method of riveting the buckets into the wheels and shrouding is shown in Fig. 7.

A marine-type thrust bearing adjustable and easily replaced maintains the rotor in its proper position. The unit is mounted on a heavy cast-iron bedplate. The lagging outside the turbine cylinder is covered with enameled sheet iron which protects the insulation and gives a finished appearance to the machine.

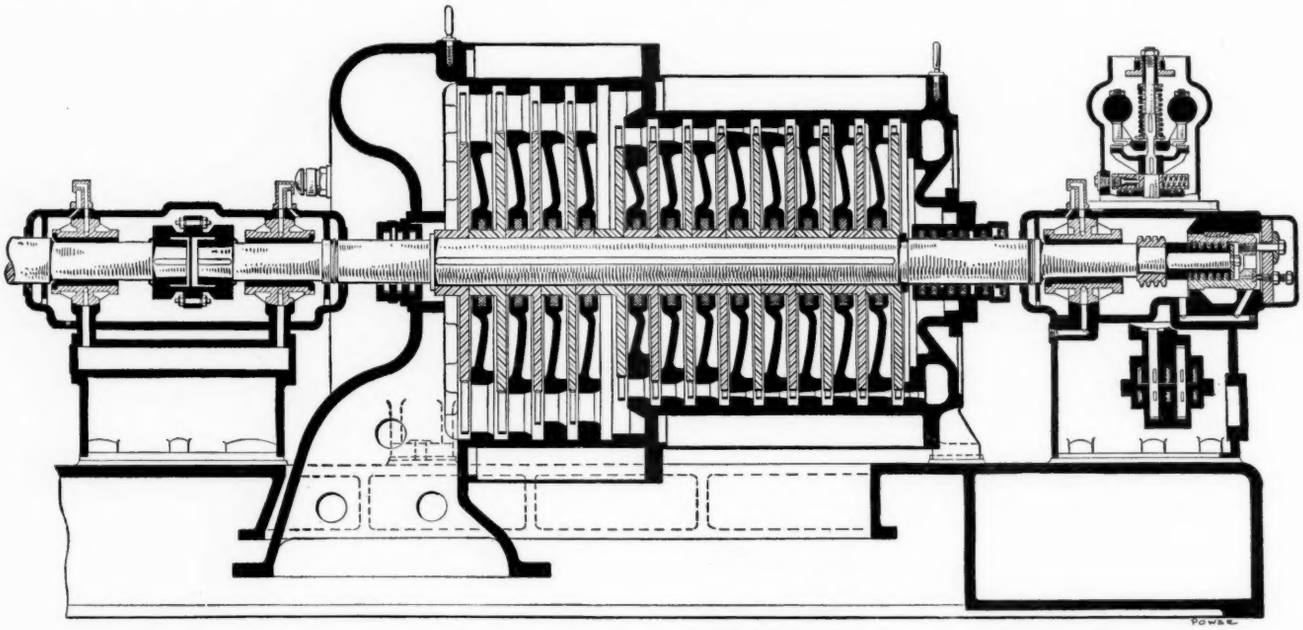


FIG. 5. SECTION THROUGH TURBINE

A small turbine-driven centrifugal pump, with the impeller submerged in the oil reservoir, forces the oil to the bearings before the machine is turned over. After starting, a spur-geared oil pump, directly connected to the governor spindle, forces oil under 6 lb. pressure to every bearing. The oil drains back by gravity to a large reservoir in the bedplate, where it is strained and water cooled. An independent emergency governor, operating a quick-closing throttle valve, which is moved by oil under 30 lb. pressure, is used.

The bearings are of heavy-pedestal type and ring oiled.

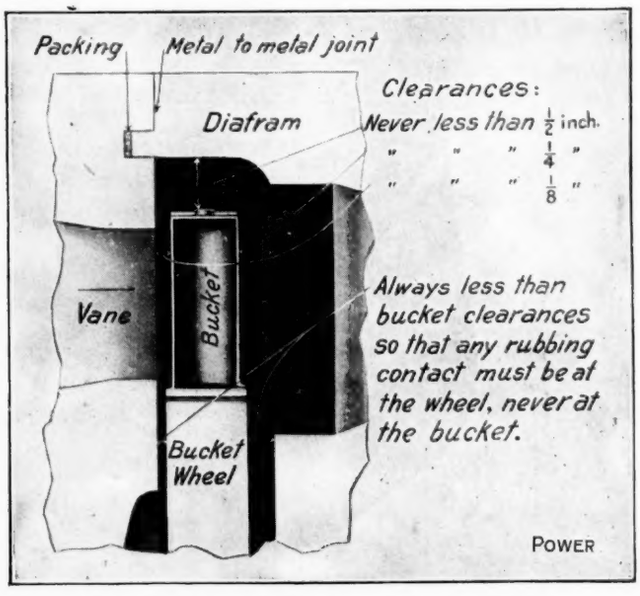


FIG. 6. SHOWING CLEARANCE OF BUCKETS

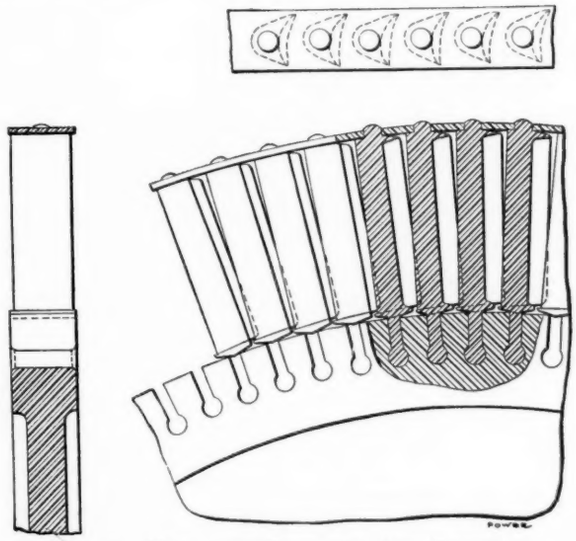


FIG. 7. HOW THE BUCKETS ARE SECURED

Panama Electrical Engineers Form Section—The American Institute of Electrical Engineers has authorized the formation of a Panama section. There are some thirty members of the Institute now on the Isthmus.

Italian Thirteen-Million-Dollar Water-Power Plant—The Italian Parliament has passed an act authorizing the construction of a 150,000-hp. hydroelectric development in Calabria, in southern Italy. The contemplated construction will require the erection on a grand scale of three dams at an estimated cost of some $13,000,000. In the aggregate it is expected to supply about 150,000 hp. for traction, illumination, and the development of industries, not only in Calabria, but also in Apulia and throughout southern Italy in general. Energy will also be employed on a large scale for irrigation purposes—"Electrical World."

Computing Charts for Closed Heaters

By W. J. Demorest

SYNOPSIS—By means of charts, when drawn to large scale, the required distribution of heat between primary and secondary heaters and also the coal saving and cost of heaters may readily be obtained without resorting to long arithmetical calculations for each set of conditions.

In the February, 1902, issue of Power, there appeared an article by C. G. Robbins on "Feed Water Heaters in Condensing Plants." It is the purpose of the present

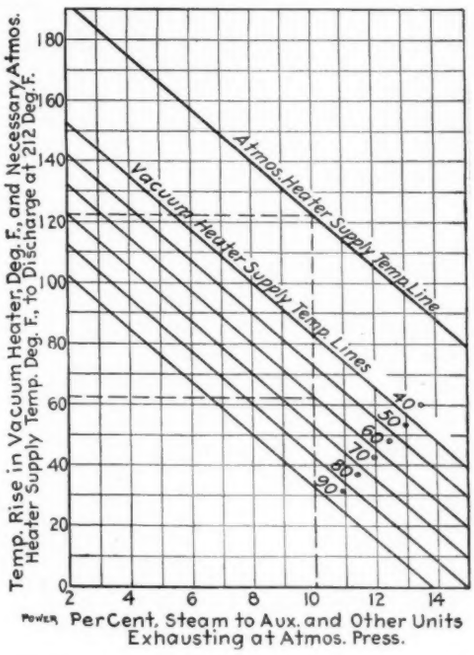

Temp. Rise in Vacuum Heater, Deg. F., and Necessary Atmos. Heater Supply Temp. Deg. F., to Discharge at 212 Deg. F.
Atmos. Heater Supply Temp. Line
Vacuum Heater Supply Temp. Lines
40°
50°
60°
70°
80°
90°
Per Cent. Steam to Aux. and Other Units Exhausting at Atmos. Press.
POWER

Fig. 1. Temperature Rise in Vacuum Heater and Necessary Initial Temperature of Water for Atmospheric Heater to Discharge at 212 Deg.

article to show how charts may be prepared to obtain, for given conditions, the results of computations, such as pointed out by Mr. Robbins' article, without employing tedious arithmetical computations; and also to give the coal-pile saving and the initial cost for the heater installations.

Fig. 1 is to aid in determining the proper distribution of the heating process between atmospheric and vacuum heaters. The latter are usually known as primary heaters. On occasions the condenser itself has been used as the primary heater, the circulating water taking the heat from the steam and passing on to the atmospheric heater. The horizontal scale gives percentages of the total steam generated by the boilers used by auxiliaries or any units exhausting at atmospheric pressure. Following any vertical line up to a single heavy diagonal line running across the chart and over to the scale on the left-hand side, gives the temperature at which the atmospheric heater must receive the water if it is to be discharged at 210 deg. F. If the water does not drop in temperature in passing from the vacuum heater to the atmospheric heater, this will also be the vacuum-heater discharge temperature. In computing the values for this line, it was assumed that 90 per cent. of the steam exhausted at atmosphere was condensed in the heater, each pound condensed giving 970.4 B.t.u. to the feed water. On the same chart is plotted vacuum-heater temperature rise with various feed-water supply temperatures. This is obtained by subtracting the temperature of the feed-water supply from the temperature of the supply to the atmospheric heater.

Fig. 2 is for computing the heating surface required to obtain different heating conditions, and also to find the cost of the heater. The curves in the lower left-hand corner are plotted between final water temperature and mean temperature difference,* several curves being drawn for various rises in temperature.

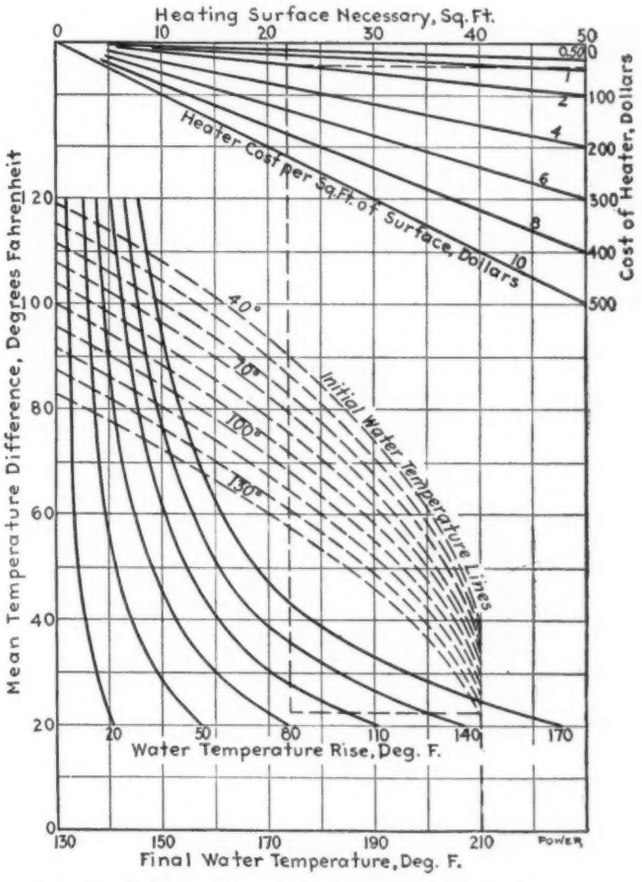


Fig. 2. Heating Surface Required and Cost of Heater

*The formula used for figuring the mean temperature difference was:

$$M = \frac{I - F}{\text{Nap. log } \frac{I}{F}}$$

where
M = Mean temperature difference;
I = Temperature difference between steam and water entering heater;
F = Temperature difference between steam and water leaving heater.

The dotted curves immediately above are plotted between mean temperature difference and square feet of heating surface necessary when heating 1000 lb. of water per hour, the coefficient of heat transfer being 180 B.t.u. per hr. per sq.ft. of heating surface per degree mean temperature difference. This is as high as can be counted on continually when the tubes are liable to get coated with oil, although values of this constant of over 300 would represent conditions in new heaters, when the tubes are clean. The units in which the coefficient is expressed explain how the computations were made for these curves. The set of curves at the top of the chart is plotted between square feet of heating surface and cost of heater. The values for these curves were obtained by multiplying the square feet of surface by the cost of surface per square foot.

Fig. 3 can be used for computing the coal-pile saving in a plant by a feed-water heater installation. All curves on this chart give values corresponding to a water consumption, at rated load, of 1000 lb. per hr. In the lower right-hand corner is plotted a series of curves showing the relation between hourly heat returned to the boilers by heating the feed water, and corresponding coal heat saved for various boiler efficiencies. The coal-heat saving is obtained by dividing the water-heat saving by the boiler efficiency. Then for various heat-unit contents per pound of coal, it is possible by division to get the hourly coal saving in pounds, which is the basis for the other set of curves at the bottom of the chart. Multiplying the hourly coal saving in pounds by the cost of the coal in cents per pound, gives the hourly coal-pile saving in cents. In this way the values were figured for the full lines at the top of the chart. Ten cents per ton was added to the cost of the coal for handling. Now multiplying the hourly saving by 8760 (hours per year) and by the load factor, gives the net yearly saving in coal, shown by the dotted lines at the top of the chart. It must be remembered that this gives the coal saving only. To get the total net saving it is necessary to add the saving due to less boiler capacity being required and subtract the cost of interest, depreciation, labor, etc., incident to operating the heater. These elements cannot be readily plotted so as to be of any use.

To fully demonstrate the method of using the charts the following problem is traced on them. Assume 5000 lb. of steam generated per hour, 60 deg. F. feed-water supply, 10 per cent. of steam to auxiliaries, vacuum heater cost $4 per sq.ft., atmospheric heater cost $2 per sq.ft., 70 per cent. boiler efficiency, 13,000 B.t.u. per lb. of coal, coal cost $3 per ton, and 30 per cent. load factor. In Fig. 1 read up from 10 per cent. to the upper heavy line and to the left to find that the atmospheric heater must be supplied with water at 122.5 deg. F. to discharge it at 210 deg. F. Reading to the left from the 60-deg. water-supply temperature line, gives 62.5 deg. as the required temperature rise in the vacuum heater. Assume no cooling of the water between the heaters. Passing to Fig. 2 read up from 210 deg. F. final water temperature of the atmospheric heater to 122.5 deg. F. initial temperature, then over to 87.5 deg. temperature rise and up to the heating-surface scale, which shows that 21.8 sq.ft. of surface will be needed per 1000 lb. of steam per hour. It would then require

$$5 \times 21.8 = 109 \; sq.ft.$$

for the 5000 lb. per hr. Reading across from the line representing a heater cost of $2 per sq.ft., the cost of the required heater is found to be

$$\$44 \times 5 = \$220$$

In Fig. 3, which may be used for any device which returns heat to the boilers, read up from 87,500 B.t.u. of heat returned to the boilers per hour to the 70 per cent. boiler-efficiency line, to the left to the line for 13,000 B.t.u. per lb. of coal, up to the line representing a coal cost of $3 per ton, to the right as far as the line for 30 per cent. load factor, and down to the yearly coal-pile saving, reading $38. Then the total yearly coal-pile saving by a heater under the assumed conditions of the example would be

$$5 \times \$38 = \$190.$$

The fine dotted lines on the charts show the paths followed in solving this problem. The cost and yearly coal-pile saving for the vacuum heater might be solved in a

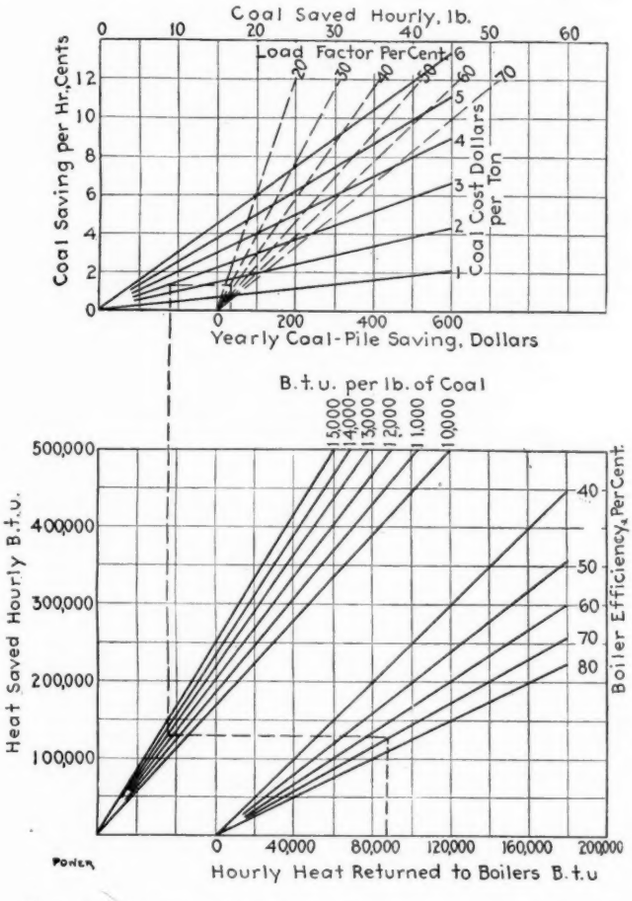

Coal Saved Hourly, lb.
0 10 20 30 40 50 60
Load Factor PerCent. 6
20 30 40 50 60 70
Coal Saving per Hr. Cents
0 2 4 6 8 10 12
Coal Cost Dollars per Ton
1 2 3 4 5
0 200 400 600
Yearly Coal-Pile Saving, Dollars
B.t.u. per lb. of Coal
15,000 14,000 13,000 12,000 11,000 10,000
Heat Saved Hourly B.t.u.
100,000 200,000 300,000 400,000 500,000
Boiler Efficiency, PerCent.
40 50 60 70 80
0 40,000 80,000 120,000 160,000 200,000
Hourly Heat Returned to Boilers B.t.u.
POWER

FIG. 3. SAVING IN COAL EFFECTED BY HEATERS

similar manner, but are not traced on charts 2 and 3 because of the complication of lines which would result.

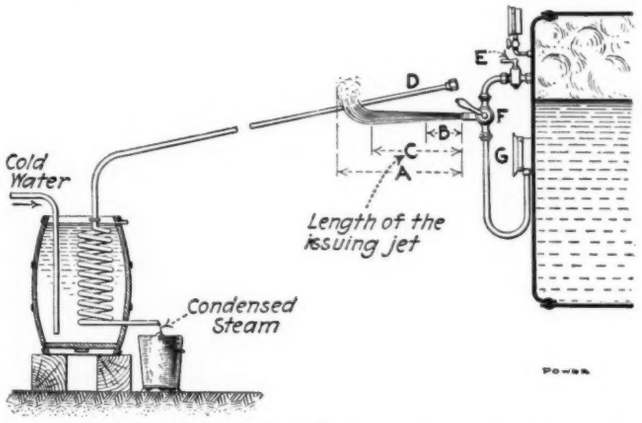
There are bound to be errors of some magnitude in the results obtained from the use of such charts unless they are drawn to large scale. The results obtained, however, should be as accurate as the assumptions upon which computations must be based.

In order, therefore, that the technical man who in material things knows what to do and how to do it, may be able to get the thing done and to direct the doing of it, he must be an engineer of men and of capital as well as of the materials and forces of nature. In other words, he must cultivate human interests, human learning, human associations, and avail himself of every opportunity to further these personal and business relations.—"Johnson."

Measuring Steam Leakage

It is a practice among engineers to close the steam and the exhaust valves, then to open the indicator cock, after the cylinder has had time to fill with steam, and judge by the duration and intensity of the discharge how badly the inlet valves are leaking. F. Gyseling, technical director of the Bollinckx establishment at Brussels, has carried out a series of interesting experiments to determine the quantity of steam delivered by a jet of given size based upon the length to which the jet carries.

Referring to the diagram, steam was admitted through the regulating cock *E* to the three-way indicator cock *F*, and the length of the issuing jet measured as shown, the distance *B* being that at which the hand could be held, and the distance *C* the length of the jet in the axis of the discharge, the distance *A* being the total length. The



Measuring Steam Flow by the Length of the Jet

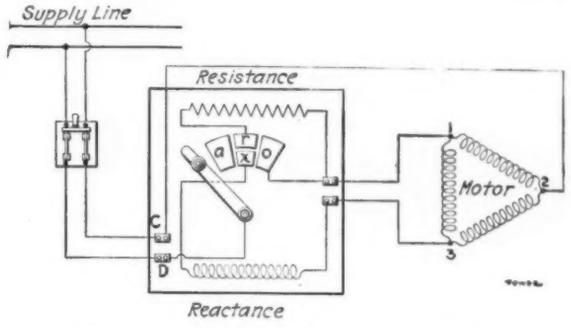
steam gage *G* indicated the pressure at which the jet issued. After the jet had been measured, and without disturbing the adjustment of the cock *E*, the pipe *D* was connected to the indicator cock and the steam discharged for an observed time, condensed and weighed. The results obtained were as follows:

	Meters	Inches	Meters	Inches	Meters	Inches	Meters	Inches	Meters	Inches
Total length (A) of jet	0.90	35.4	1.10	43.3	1.60	63.0	2.10	82.7	2.50	98.4
Length (C) of jet in axis of nozzle	0.45	17.7	0.60	23.6	1.00	39.4	1.50	59	2.00	78.7
Distance (B) at which hand can be held	0.30	11.8	0.34	13.4	0.40	15.7	0.45	17.7	0.50	19.7
	Ats.	Lb.-Sq.In.	Ats.	Lb.-Sq.In.	Ats.	Lb.-Sq.In.	Ats.	Lb.-Sq.In.	Ats.	Lb.-Sq.In.
Pressure on gage C condensing	0.	0.	0.	0.	0.04	0.59	0.19	2.79	0.24	3.53
Pressure on gage D discharging tests	0.	0.	0.	0.	0.02	0.29	0.16	2.35	0.22	3.23
Pressure in boiler	7.50	110.2	7.50	110.2	7.55	111.	7.60	111.7	7.60	111.7
	Kg.	Lb.	Kg.	Lb.	Kg.	Lb.	Kg.	Lb.	Kg.	Lb.
Weight of steam discharged per hr.	2.98	6.55	4.18	9.2	11.63	25.59	29.235	64.32	33.28	73.21

Applying Instruments to Split-Phase Starters

In applying the voltmeter and ammeter to test a three-phase motor operated from a single-phase line by means of a reactor-resistor phase-splitting starter, the fact that the motor is started as a three-phase machine but operates as a single-phase motor, is to be borne in mind; otherwise the readings obtained may be wrongly interpreted.

In the accompanying diagrammatic sketch of such a starter, it will be noted that only when the starter handle rests on segments *r* and *x* do all the motor leads carry current. As soon as the starter handle is moved to the running position *o*, the motor lead that is connected to the reactance becomes dead as far as carrying motor current is concerned. Therefore, an ammeter connected into it would indicate current only on the starting position of the starter. Furthermore, only when a voltmeter is applied to the motor leads 1 and 2 will the actual voltage of operation be indicated, because when the instrument is applied across either of the other two legs, it has in series with it one motor coil that acts as a multiplier to



Sketch of Split-Phase Starter

decrease its reading.

An operator, whose real trouble was heavy overload, measured the voltage across the three legs of his motor; when he got 95 volts on each of two legs and 110 volts on the third one, he attributed his trouble to unbalanced voltages and called in an inspector to locate the cause.

Overmotoring

By overmotoring is meant the use of a motor that is too large for the duty that it has to perform. To have a motor sufficiently large for the work is good judgment; to have it too large may represent investment that occupies floor space and pays no interest.

For a motor that operates under steady load, heating is the criterion; for one that is subjected to frequent starts, sparking at the brushes is usually a safe guide, assuming that the starting devices have the proper characteristics. From a meter point of view, it is advantageous to have a motor operate at high efficiency; for motors operating on steady loads, this means loads of from 75 to 125 per cent. of full load. With motors on intermittent service, such as railways, the higher efficiencies may obtain at lesser loads.

Ordinary induction motors and compound-wound and shunt-wound direct-current motors, have no speed complications incident to light loads. Induction motors are selected to operate at or near full load not only because the resulting efficiencies are better, as is true of all motors, but at light loads they have poor power factors tending to lower the power factor of the system on which they operate. Series motors may be even dangerous on light loads, because under such a condition they tend to race and the extent to which they race depends upon how light the load is. Racing, especially where the mechanical load is connected through gears, sets up vibration tending to deteriorate all mechanisms within its influence.

Vibration also reacts upon the motor bearings, and centrifugal forces, incident to excessive speed, subject the armature to stresses beyond what they may have been designed to withstand.

An inspector was called in to locate the trouble with a series motor-operated electric crane, the electrical equipment of which had given considerable trouble. All three crane motions were derived from the same motor, one motion or the other being engaged by means of a lever mechanism; this meant that when the crane was being used, the motor ran continuously during much of the time. The load was imposed through a train of gears, so that the speed was abnormally high.

Application of an ammeter showed that with the heaviest load the crane would be called upon to handle, the motor would not be half loaded. The situation was temporarily relieved by connecting a resistance into the supply circuit, and it was permanently relieved by the substitution of a motor of about half the rating of the first machine.

Losses in Boiler Operation

By Victor J. Azbe

SYNOPSIS—The eight chief factors producing heat loss in boiler operation are: Heat carried off by flue gases; incomplete combustion; unburned carbon escaping up the chimney or depositing in the boiler, etc.; unburned carbon dropping through the grates; moisture in the fuel; formation of water by the combustion of hydrogen; water vapor in the air; and radiation. The author discusses these losses, their relative importance and means for preventing or minimizing them.

Heat Carried Off by Flue Gases

The temperature of the escaping gases is greatly influenced by the area and condition of the heating surface. If the heating surface is maintained clean, inside and out, the temperature can only be reduced by increasing the area. Thus, economizers are often advantageous. Economizers, however, usually require mechanical draft and the interest on the cost of installation, maintenance expense, etc., must be carefully considered in connection with the saving in fuel cost to be obtained.

The economizer increases the heating surface; the flue brush, tube cleaner and scale-preventing methods increase its efficiency. Soot is one of the poorest conductors of heat. There are only two substances which exceed soot in this respect, wool and feathers. Asbestos is a poor conductor of heat and, hence, is used for covering steam pipes. If the boiler-heating surface were covered with asbestos 1½ in. thick, no power-plant manager would spare any effort or expense to remove this covering as soon as possible. Soot is probably five times as poor a conductor of heat as asbestos, thus, ¼ in. of soot is equal in value to 1¼ in. of asbestos.

Scale also is a poor conductor of heat. Its conductivity cannot be stated because this varies with its composition. Even though the conductivity of soot is greater than that of scale, scale is more dangerous to the boiler, because soot simply prevents the gases from coming in contact with the shell and giving up their heat to the water in the boiler, while scale prevents the water from coming in contact with the boiler plates and absorbing the heat. Consequently, if the heat is supplied to the metal faster than it is absorbed, the plates and tubes are in danger of being overheated.

If the amount of air supplied per pound of coal is known, it is comparatively simple to calculate the loss due to the heat carried off by the flue gases. Multiply the weight of the gases formed (weight of air supplied plus weight of combustible per pound of coal) by the specific heat of the gases and the difference in temperature between the gases and the outside air. Thus, if the gas analysis showed that 17 lb. of air was being supplied per pound of coal; if the coal contained 80 per cent. combustible matter and the temperature of the flue gases was 500 deg. F. and that of the outside air 70 deg., the heat carried off per pound of coal would be

$(17 + 0.80) \times (500 - 70) \times 0.24 = 1837$ *B.t.u.*

(0.24 is the commonly accepted figure for the specific heat of the flue gases).

By careful regulation of the air supply the heat lost with the flue gases can be kept within reasonable limits. Every pound of air put through the furnace in excess of what is required by good operation only serves as a sponge to soak up heat and carry it off to no useful purpose. It is safe to say that, in the average boiler room, where conditions are not carefully controlled, 40 per cent. or more of the latent heat of the fuel is lost, of which at least one-quarter could be saved. In some power plants the writer found the conditions so bad that 50 per cent. of the coal fired was as good as thrown away. There were very few plants in which the preventable loss amounted to less than 10 per cent.

To prevent waste through excess air close attention must be paid to the draft and fuel bed. Most plants suffer from too thin a fire or too strong a draft. A CO_2 recorder or, at least, a hand gas-analyzing instrument with a gas collector, and a draft gage, would enable the engineer to prevent wastes by adjusting the draft to the thickness of the fuel bed, or the thickness of the fuel bed to the draft. Without them close adjustment is impossible. When the draft is increased without a change being made in the thickness of the fuel bed the rate of boiler output is somewhat increased, but the efficiency of combustion is lowered. The amount of draft that should be used is that which will supply the right amount of air for the fuel on the grates, and when the correct amount is used the analysis of the flue gases will show a high percentage of CO_2. In plants having more than one boiler in service the draft should be equalized in all the furnaces. In many plants twice as strong a draft is used in one boiler as in another. Often the boiler nearest the chimney and with the stronger draft will use too much air and thus waste fuel, while a further boiler with a weak draft will not get enough air and, hence, will produce smoke and waste fuel through incomplete combustion.

Incomplete Combustion and Smoke

The second and third causes of heat loss are incomplete combustion and the escape of unburned carbon up the chimney. Incomplete combustion is caused by insufficient air, low temperature, or the imperfect mixture of the combustible gases with the air. Carbon when completely burned gives up 14,600 B.t.u. per pound. When incompletely burned the heat generated is less than one-third of this, or 4450 B.t.u. In the first case the carbon and oxygen combined in the proportion of 1 lb. of carbon to $2\frac{2}{3}$ lb. of oxygen. In the second, 1 lb. of carbon combined with half or only $1\frac{1}{3}$ lb. of oxygen.

The volatile matter of the coal burns in the combustion chamber; the fixed or free carbon burns on the grates. From this it is seen that the larger the percentage of volatile matter in coal, the larger and roomier the combustion chamber should be. Coal that can be burned smokelessly in one furnace may smoke badly in another. Anthracite is practically smokeless because it contains very little volatile matter. Bituminous coals cannot be burned smokelessly in furnaces constructed for anthracite. With bituminous coals the boiler shell or tubes must be placed some distance from the grate to prevent the gases from coming too quickly into contact with the comparatively cool metal. The temperature of the boiler shell is but slightly above the temperature of the water in the boiler, which at 100 lb. steam pressure is 337.5 deg. F. This is far below the ignition point of the combustible gases and vapors some of which decompose and precipitate carbon which deposits on the heating surface of the boiler as soot or escapes through the chimney as smoke.

To prevent incomplete combustion and insure smokelessness, first, the required amount of air must be admitted; second, this air must be brought into contact and mixed with the combustible gases, and, third, a high furnace temperature must be maintained. Any one or two of these conditions will not prevent the loss due to the formation of CO or smoke. With hand-fired furnaces, to supply the required amount of air for the complete combustion of the volatile combustible matter when fresh coal is put in, it is often necessary to admit some air above the bed. Most of the so called smoke consumers, which should be called smoke preventers, are constructed on this principle of admitting air above the fire. The main trouble is that it is practically impossible to admit the correct amount and the cold incoming air chills the furnace and arrests combustion.

This air supply above the fuel bed is required only while the distillation of volatile matter is heavy, as for a few minutes after a new charge of coal, and the supply should be shut off as soon as smoke ceases to escape. Smoke indicators are of value because they show the fireman whether smoke is being emitted or not, and they assist him to determine what amount of air he ought to use to prevent smoke. The actual loss due to smoke alone, which is very small, is generally overestimated. With the very densest smoke the loss never amounts to more than 2 per cent. of the coal fired. If this were the only loss smoke could be neglected in most cases, as far as economy goes. But smoke is always accompanied by valuable combustible gases and vapors.

There are objections to smoke from the hygienic standpoint and others, but as these do not come under the head of power-plant operation, they are neglected here.

While smoke always indicates imperfect combustion, the absence of it is no indication of ideal conditions, because the invisible combustible gases may be escaping undetected. In down-draft furnaces the volatile matter passes through the highly-heated fuel bed and if the air supply is sufficient, this volatile matter will be completely consumed. If, however, the air supply is insufficient, waste results, although smokeless conditions will still be maintained. This is because, when CO_2 comes in contact with incandescent carbon, it gives up half of its oxygen to form double the amount of CO.

Properly designed dutch ovens are valuable as smoke preventers. In them the burning of the fuel takes place in a chamber separate from the space where with the ordinary arrangement of furnace the fuel is burned. With such design there is less danger of combustion being checked due to the flame coming in contact with a cool surface as the furnace is of brick throughout and the bricks act as heat accumulators. When a fresh charge is thrown in, vaporization of the moisture and gasification of the volatile matter take place, both of which processes require heat. As the brick walls are at a high temperature, they give off heat and thus prevent the furnace temperature from dropping below the ignition point of the combustible gases.

Unburned Carbon Dropping Through Grate

The fourth loss, due to the unburned carbon dropping through the grate, depends greatly upon the percentage of ash in the coal. A high percentage of ash in the coal means a high percentage of unburned carbon falling through the grate because the fire needs more frequent cleaning and hence more unburned coal is lost. A high ash content is also objectionable in other ways. The larger the percentage of ash, the smaller the percentage of combustible matter. High ash makes good air distribution difficult and, hence, frequently requires an unusually large excess air supply. High ash also increases the labor cost. The air spaces in the grate must be large enough to allow the required amount of air to flow through, but at the same time they must not be too large, else too much unburned fuel will fall through.

Moisture in Fuel

The fifth loss is that due to the moisture in the fuel. To heat 1 lb. of water 1 deg., 1 B.t.u. is required. To evaporate this pound of water from 212 deg. into steam at the same temperature, 970.4 B.t.u. are needed. To superheat this pound of steam 1 deg. requires about 0.45 B.t.u. To illustrate how the loss due to the moisture is calculated, assume a coal containing 5 per cent. moisture; the temperature of the coal when fired is 70 deg. and the temperature of the flue gas 500 deg. To raise the temperature of the water contained in 1 lb. of coal from 70 to 212 deg., would require

$$0.05 \times (212 - 70) = 7.1 \textit{ B.t.u.}$$

To evaporate this water into steam would require

$$0.05 \times 970.4 = 48.52 \textit{ B.t.u.}$$

And to superheat the steam from 212 to 500 deg. would require

$$0.05 \times (500 - 212) \times 0.45 = 6.48 \textit{ B.t.u.}$$

Adding these quantities together gives 62.10 B.t.u., which is lost with each pound of coal burned. If the coal had a heat value of 12,000 B.t.u. as fired the percentage of loss would be

$$62.1 \div 12{,}000 \times 100 = 0.52 \textit{ per cent.}$$

This is not much, but, considering that this moisture was paid for the same as the combustible matter of the coal, and, of each hundred dollars spent, five dollars went to pay for the moisture, it is not only useless, but causes a loss in the furnace as well.

In some plants a practice is made of wetting the coal. No doubt with some coal, especially slack, this is beneficial. The engineer should remember, however, before allowing the fireman to wet the coal more than merely necessary to prevent dust, that the larger the amount of water evaporated in the furnace, the smaller will be the amount evaporated in the boiler.

Formation of Water

The sixth loss is due to the moisture formed by the combustion of the hydrogen in the coal. This hydrogen content runs from 3 to 6 per cent. In burning, hydrogen combines with oxygen and forms water, 1 lb. requiring 8 lb. of oxygen and forming 9 lb. of water. About 18 per cent. of the heat credited to the hydrogen is lost when it is burned in the furnace. The heat value of a pound of hydrogen obtained when it is burned in a calorimeter, where the products of combustion are cooled to about ordinary atmospheric temperature and then calculated to a basis of 32 deg., is 62,000 B.t.u. In a boiler furnace the gases ordinarily escape at a temperature of 500 deg. or more, which is far above 212 deg., the point where the vapor would begin to condense and give up its latent heat. Thus, this latent heat is lost as well as all the sensible heat of both water and vapor above the temperature on which the heat value of hydrogen is based.

Water Vapor in the Air

The seventh loss is that due to the water vapor in the air. The loss per pound of coal fired, due to moisture in the air, is calculated by multiplying the weight of the moisture contained in the air supplied per pound of coal, the specific heat of steam (water vapor) and the difference in temperature between the flue gases and outside air. The weight of moisture in the air is found by multiplying the relative humidity, expressed as a fraction, by the weight of moisture in 1 lb. of air saturated with moisture. As the direct loss due to moisture in the air is small, and cannot be controlled, and as the data needed to estimate this loss are not often available, this loss is seldom entered as a separate item in the heat balance, but is simply included in the "unaccounted-for" item.

Radiation

The eighth loss is that due to the radiation of heat from the furnace walls. To lower this loss boiler settings are generally constructed with double walls with an air space between and until recently the opinion prevailed that the air, which is a very poor conductor of heat, served greatly to prevent the heat from being conducted through the walls. However, recent tests made by the government proved that this is not so and that a solid wall is a better insulator than two walls with an air space between. The conduction of heat by the air space is really smaller but the radiation across the empty space is great. For this reason it is desirable to fill this air space with some loose material as sand, broken brick, etc. It is good practice to cover the outside surface of the boiler walls with some nonconducting substance as asbestos, magnesia, etc. This not only diminishes the escape of heat from the boiler settings, but also the air infiltration through the brick work.

In conclusion, it is well to give due attention to the condition of all boiler walls, for in many plants 5 per cent. or more of the coal is wasted simply because the walls are cracked and allow air to leak into the furnace.

Furnace Losses and Air Requirements

By Haylett O'Neill

It is the purpose of the accompanying charts to show graphically the furnace losses resulting from incomplete combustion of coal, as indicated by the percentage of carbon monoxide (CO) in the flue gas and also to show the amount of air required, as in a forced-draft equipment, to produce a certain combustion. A very small percentage of CO represents a large loss, especially if the

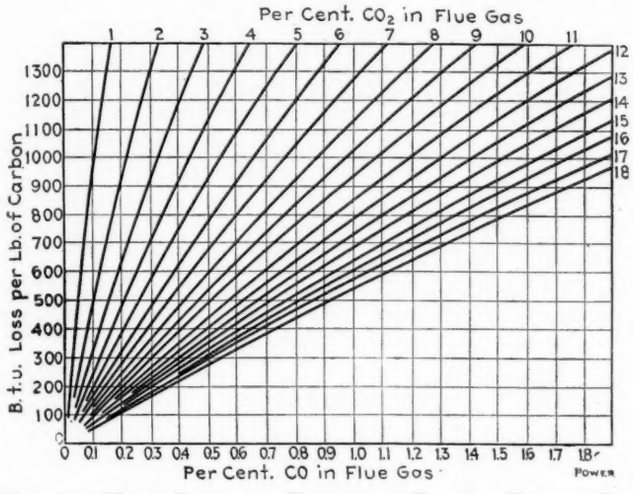


Fig. 1. Heat Loss per Pound of Carbon Due to Incomplete Combustion

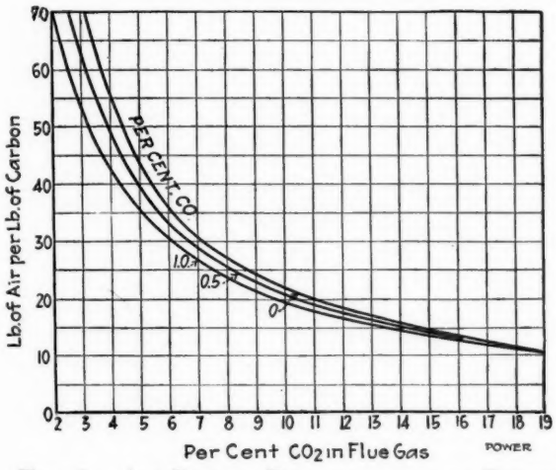


Fig. 2. Air-Supply Requirements to Produce a Certain Combustion

percentage of CO_2 is small. For example, assuming products of combustion of coal running 14,300 B.t.u. and 80 per cent. carbon, to contain 6 per cent. CO_2 and 0.2 per cent. CO, the loss on account of CO is 325 B.t.u. per lb. of carbon, or 260 B.t.u. per lb. of coal. With gas containing 16 per cent. CO_2, the loss is 130 B.t.u. per lb. of carbon, or 104 B.t.u. per lb. of coal. The charts are self-explanatory and convenient for ready reference.

Experience with Closed Water Heaters

By A. C. Waldron

SYNOPSIS—Some troubles with leaky feed-water heaters of the closed type are described. The pressure put on closed heaters by the expansion of the water is usually the cause of leaks.

One of the most common troubles experienced in taking charge of steam plants is to find the feed-water heater leaking water from the outer casing and bolted flanged joints. Upon inquiry one is invariably informed that the heater had always leaked, for it is not always an easy matter to pack the flanges, and again it is generally a Sunday or a night job. In one plant the writer had a hot-water heater, Fig. 1, which consisted of a 2½-in. coil, which carried cold water and through this coil was passed a ¾-in. brass, live-steam pipe connected to a trap. At the end of the coil was a thermostat which, by turning the wheel *A* either way, would set it to operate for either hotter or colder water. The diaphragm valve was operated by city water pressure. The pet-cock *B* had to be kept slightly open all the time so that when the thermostat shuts the city pressure off the ¼-in. pipe *B*, the open pet-cock *D* will relieve all pressure and the spring *C* will push up the diaphragm and open the valve *D*, admitting more live steam to the coils.

The bolted flanges $E_1E_2E_3E_4E_5$ were invariably leaking, especially after the valves *F* and *G* were closed, as there was no relief valve on this coil, and the water was allowed to heat up, producing a pressure of about 500 lb., due to the expansion of the water. It was not until after a relief valve was put on that the flanges could be kept tight.

Fig. 2 shows a heater found leaking at the flanges A_1A_2. The cap at the top leaked so badly that water would accumulate in the steam space, and cause serious water-hammer. This heater did not have a relief valve and so had to withstand high water pressures when the feed-water valves were closed. Copper and lead gaskets were renewed frequently on the flanges of several such heaters. The writer has operated the heater, Fig. 3, which, because of its construction, allows for expansion. The pressure in this type of heater is confined to the coils. A relief valve should be attached to the heater coil between the heater and the outlet valve. The relief valve on the heater referred to was set to operate at 200 lb. pressure,

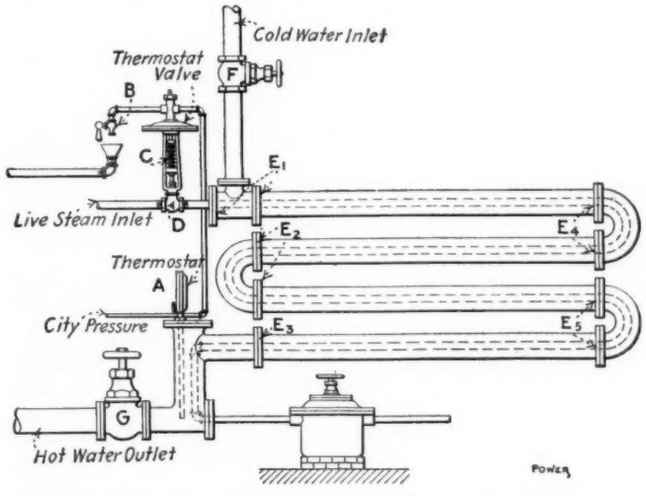


Fig. 1. Flanges Leaked on This Coil Heater

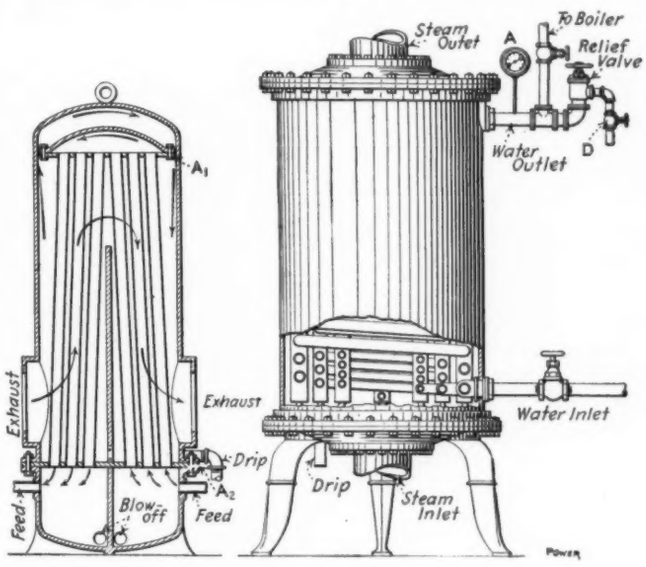


Fig. 2. Fig. 3.

Fig. 2. The Large Flanges A_1 and A_2 Leaked Due to High Pressure. Fig. 3. Expansion of Water Subjected This Heater to 500 Lb. Pressure.

and every night when the valves on the inlet and outlet of the heater coil were closed, the relief valve would run a stream of water while the engine was running.

Determined to ascertain how much pressure would accumulate if the relief valve was made inoperative, the writer put a steam gage which registered up to 300 lb. at *A* and a valve at *D* and closed the valve *D*. Steam was sent to the heater and the gage pointer started to move, and went around by the 300 mark and hard up against the stop pin. The approximate pressure in the coils and piping due to the expansion of the water was 500 lb. but even at this pressure the tubes did not show any signs of leaking.

It was next decided to determine the cubical contents of the coils by filling them with water at 60 deg. F. The water was drained out and found to weigh 78 lb., or 1¼ cu.ft. Next, the coils were filled with water at 62 deg. F. until water came out of the opening into which the nipple holding the gage had been screwed. Exhaust steam was applied and the water caused to expand, the overflow water being caught in a pail. While heating up to 212 deg., 4 lb., or roughly $^1/_{15}$ cu.ft. of water was forced out of the opening and into the pail. This illustrates what a crowding effect there is in closed heaters having no relief valves.

It is too common for firemen to close all the feed valves, thus subjecting a closed heater and the feed lines to pressures that frequently produce serious leaks.

Drying Out Generators and Motors

By H. M. McLellan

When to Dry Out—No machine should be put into service or subjected to a breakdown insulation test when the insulation is damp. This applies to starting up after a long shutdown, as well as to the original start. In some cases the presence of moisture may be detected by inspection, but in others the insulation may be damp yet appear quite dry to the touch. To determine definitely the condition of the insulation, the insulation resistance should be measured. This may be done by means of a megger,* or by the use of direct current and a high-resistance voltmeter. When it is impossible to measure the insulation resistance, it is advisable to dry out the machine as a precautionary measure, for if the drying is properly done, no harm can result.

Whenever insulation resistances are less than the values given below, it may be assumed that the insulation is damp, and the drying out must be continued till these values are obtained.

Machine Voltage	Minimum Insulation Resistance Cold
700 and below	1 megohm (1,000,000 ohms)
Above 700	1500 ohms × voltage of machine

When the machine is heated, the insulation resistance will drop considerably. Therefore, it is necessary to allow the machine to cool after drying before a comparative reading can be obtained.

Time Required—The length of time required for drying will depend upon the thickness of the coils and insulation, upon the condition of the insulation with regard to dampness, and upon the temperature at which the machine is maintained while being dried out. Twenty-four hours is the shortest time that the drying out should be continued before letting the machine cool and taking a resistance reading. The rate of heating should be such that the maximum temperature will be reached in from three to four hours. Resistance readings should be taken from time to time as the machine cools off, for these readings may indicate whether the drying has been carried far enough without waiting for the machine to cool.

Caution—Several thermometers should be placed in contact with the coils, which should be kept at a temperature of about 60 deg. C. (140 deg. F.)

While being dried out, the machine must never be left without attendance, and temperature readings must be taken at regular intervals. Failure to follow these instructions may mean the destruction of the winding through overheating.

Methods Employed

Alternating-Current Generators—Short-circuit the armature windings, putting an ammeter in at least one phase. Bring the machine up to speed, and strengthen the field until about 1¼ times full-load current flows through the armature. When the desired temperature is reached, the current should be held steady at this value. If the machine is run at less than full speed, the ventilation will not be so good and less current will be required for heating.

Synchronous Motors—A synchronous motor may be treated exactly as a generator. In this case it must, of course, be driven by some external means.

*An instrument consisting essentially of a high-tension magneto and galvanometer and calibrated to read in megohms.

Slip-Ring Motors—Where direct current is available, the motor may be treated as a generator, by short-circuiting the stator winding and impressing direct current on two of the rotor slip-rings. It is, of course, necessary that the motor be driven by some external means, and the stator winding must never be opened while there is voltage on the rotor.

Squirrel-Cage Motors—The best way to proceed in this case is to lock the rotor and impress a very low voltage across the stator terminals. Since the rotor is stationary, the cooling will be poor, and considerably less than full-load current will probably be required. Usually about one-tenth normal voltage will be sufficient to produce the desired temperature, and care must be exercised to see that no part of the machine is overheated.

It is, of course, possible to dry out any alternating-current machine by passing direct current through the windings, but in general this is less satisfactory than the methods described, and provisions must be made to insure equal currents in all the phases.

Direct-Current Generators—Short-circuit the machine through an ammeter (with a shunt) and run it at slow speed with a weak field. Shut down at regular intervals and measure the temperature, and adjust the current to give the desired temperature rise. When a constant temperature has been reached, it is not necessary to shut down except at long intervals, the heating being adjusted by the current through the armature.

Direct-Current Motors—If the machine can be driven, it may be treated as a generator. If not, the armature should be securely locked and current passed through it by way of the commutator and brushes. Since the armature is stationary, less than full-load current will usually be required. A heavy tension should be placed on the brushes, to insure good contact with the commutator, and care must be taken to see that no burning occurs.

General—Another excellent method applicable to all classes of machines is that of drying with hot air from a stove. It is particularly applicable where a large number of small machines are to be dried out. The machine must be inclosed in some form of heat-insulating box, which box should, if possible, be made of sheet iron and lined with asbestos. The temperature inside the box is raised by means of an electrical resistance or by a stove. The temperature in any part of this inclosure should not exceed 90 deg. C. (194 deg. F.), and where stoves are used the smoke or gases given off should not be permitted to come in direct contact with the windings. A supply of fresh air should be admitted at the bottom of the box, and arrangements made so that after being heated it comes in contact with the windings and then escapes at the top. Where electrical resistances are being used, the wiring and resistances must be so arranged that an arc cannot possibly occur inside the box.

Measuring Insulation Resistance by Means of a Direct-Current Voltmeter

First read the voltage across the line. Then connect the voltmeter in series with the insulation to be measured

(i.e., between a commutator bar and the shaft, slip rings and the shaft or between the terminals of the winding and the frame, etc.) and read the volts again.

If R is the resistance of the voltmeter, V the reading across the busbars, V' the reading of the voltmeter when in series with the insulation, then the resistance of the insulation is

$$R' = \frac{R\,(V - V')}{V'}$$

If $R = 100{,}000$ ohms;
$V = 500$ ohms;
$V' = 100$ ohms;

$$R' = \frac{100{,}000\,(500 - 100)}{100} = 400{,}000 \textit{ ohms}$$

The resistance of the voltmeter is usually marked on the back of the instrument or on the carrying case; if not, it may be obtained from the makers. A voltmeter with as high a resistance as possible should always be chosen.

Points on Babbitting

By L. D. Allen

SYNOPSIS—Where to look for and how to avoid bearing troubles. Hints on how to secure good results when babbitting a bearing.

In a previous article,* attention was directed to the heavy frictional expense incident to the operation of machinery throughout a mill or factory; to the requirements of a good babbitt; to the fact that its wearing qualities are dependent quite as much on its structure and the way it is made and handled as on its composition; and to the properties of many of the ingredients of bearing alloys.

Cause of Bearing Troubles

In searching for the cause of bearing troubles, first look into bearing conditions; then determine whether the babbitt is a lead-based, a semi-tin-based or a tin-based metal, and, finally, break several bars of the metal to ascertain the extent of its hardness and homogeneity. If the metal is suitable for the conditions to be met, then the bearing trouble must be sought in some one or several of the following causes: Excessive bearing pressure, insufficient bearing area, journal too small, shaft out of alignment, bearing warped, metal burned or not properly stirred when applied, bearing too tight or too loose on the sides, presence of abrasive or cutting particles, defective lubricating appliances, inferior lubricants, wick glazed, clogged or leaving insufficient capillary power, oiling rings or chains broken or jammed, cups clogged, and, last but not least, negligence.

Carelessness

One of the frequent causes of bearing troubles. aside from poor or defective lubrication, is an imperfect understanding as to the proper handling of the babbitt in melting and applying it to the bearing, or else to that carelessness which often results from familiarity or a long run of successful babbittings. As an illustration, take the brakeman on a railroad train. When he first starts out he is cautious, but with increasing familiarity and good luck he becomes careless, and the unexpected occurs. There are companies which have used a certain grade of babbitt for years with satisfactory results, and then suddenly they have trouble from hot boxes, flaking metal, etc. The metal is blamed, whereas the trouble was not due to a change in its grade. Either a different man did the babbitting and did not handle the metal right in one or two important details, or the same man had had good results so long that he had gradually dropped one precaution after another until he was getting uneven mixtures, burnt metal or oxides in the bearings; perhaps the lubricant or bearing conditions had been subjected to a similar change in attention.

Pouring the Metal

Proper babbitting conditions require clean pots and ladles. A hot pot or ladle can be quickly cleaned by brushing it with powdered resin and then removing the precipitant. It is always best to melt the babbitt in a pot or kettle and not in a ladle, the latter being too small to insure an even temperature and proper stirring. It is important that the ladle should be large enough to contain more metal than is necessary to fill the bearing. If the bearing is long, be sure that the gate into which the metal is poured is amply large so that enough metal enters at a time to reach the farthest point of the bearing without chilling; otherwise the result will be an imperfect bearing.

One concern changed from a lead-based to an expensive tin-based metal because many of the bearings had cracked and rattled loose. A tougher metal was thought necessary. Accidentally, it was found afterward that the trouble had been caused by using too small a ladle in pouring. These bearings required more than one ladleful, and, while they were dipping for sufficient metal to complete the pouring, that already in the bearing would set just enough so that when the balance of the babbitt was poured a seam would form between the two parts. When this bearing was put into service the jar on the journal caused it to crack at the seam. The firm changed back to the lead-based metal, used a ladle large enough for one pouring to a bearing, and the trouble ceased.

Temperatures

Overheating the babbitt makes it brittle. Further, the hot metal tends to shrink as it comes in contact with the colder surface, resulting sometimes in a loose lining which soon cracks under heavy stress or jarring. The temperature at which to pour a metal composed of tin, lead and antimony, and not over 0.5 per cent. copper if it is a lead-based metal, not over 2 per cent. if it is a semi-tin-based metal or not over 5 per cent. if it is a tin-based metal, may be determined by inserting a white pine stick. If it is heavily browned or slightly charred, the proper

*"Bearing Metal Manufacture and Use," Mar. 3, 1914, issue.

temperature has been reached. Another indication is a yellowish tinge forming on the surface of the metal. Do not wait until a red oxide forms. A metal containing zinc or considerable copper must be heated until it can be poured freely.

The bearing into which hot metal is poured, and also the mandrel, shaft or journal, should be heated to about 200 to 300 deg. F.; otherwise the babbitt is likely to resist its contact with the cold surface, thus causing shrinkage and an imperfect bearing. A shaft or mandrel should be well chalked to insure freedom from grease and dampness. If the shaft has not been heated, the chalking will prevent the formation of blow holes and rough surfaces on the face of the bearing. Shells or bushings should be treated in the same way. Small bearings are best poured vertically and large ones horizontally, with a large gate on top for the metal. Clay is the best material to use where it is desired to keep the metal from running out.

Another frequent source of trouble is that the kettle and the bearing are too far apart; then the metals chills or separates before it is poured. When the bearing cannot be brought close to the pot a portable furnace should be used. Hold the ladle close to the bearings to prevent air bubbles and cooling, and see that there is sufficient vent for the escaping gases.

Babbitt poured into a mold or bearing at a temperature far above its proper melting point is generally coarse grained and makes a poor lining. Rapid cooling produces a fine, even grain.

Sometimes, when getting in a new lot of metal, a purchaser will compare it with some of the old metal on hand by hitting the bars together. Usually the old bar will dent the new, indicating that the new metal is softer and raising a question as to whether the grade and quality are the same as formerly. Undoubtedly, they are, if the metal manufacturer has a reputation for reliability, but the difference is that metal carried in stock for several weeks or months is harder than the same grade when first made.

Irregularities

Peening the lining of a bearing is of no special value except in the case of shrinkage, when tightening the metal in place or evening up the surface in the event of some irregularity from pouring. If it is necessary to peen the metal to tighten it, the best way is to take a round-faced hammer and tap the bearing lightly up and down a line parallel to the axis, gradually extending the blows to the right and the left until the metal is tightened in place.

Boxes should be kept snug but should not be keyed down too tightly at the start, at least not until the rough places on the bearing have been worn smooth. A journal should rest evenly on a bearing. Weight unevenly distributed by a shaft out of alignment is disastrous to the babbitt, and particularly to a lead-based metal. This defect once caused a millwright to change from a cool-running, durable, lead-based anti-friction metal to an expensive tin-based metal, which stood the stress only because of its toughness, whereas it really developed higher friction and greater cost in other directions through lack of its anti-frictional properties.

There is no excuse for a poor bearing, so far as its being a smooth, solid, good fitting casting is concerned, if all dampness and grease are removed, the mandrel or shaft and the back of the bearing are properly warmed; the shaft is wrapped with a thickness equal to the oil space required between the shaft and the bearing sufrace; if the metal is fluid, its temperature right and it is thoroughly stirred and all oxides removed; if the gate into which the metal is poured is large enough to admit a volume that will reach all parts of the bearing quickly before chilling at any one point.

If a bearing warms up when first started, it is usually because of the little uneven projections that are being worn down. By letting the bearing run a few moments, stopping it to cool off and then starting it again, a cool-running bearing usually results, other conditions being all right.

If a metal flakes off or contains hard and soft spots and is pronounced too soft, it is usually because the metal has been left too long in a highly fluid state without stirring. This allows the metals to separate, and instead of a homogeneous mixture there is a segregation of the lead, tin and antimony, and trouble naturally follows.

Grades of Babbitt

Bearing metals should be selected according to the speeds and pressures, the size of the bearing and the thickness of the babbitt lining. It is not necessary that a different babbitt be used for each slight variation, but a different grade is preferable where the conditions are radically different. Practically three grades will cover all mechanical conditions; one for general light work, one for medium-speed and pressure and one for high-speed, heavy-duty work, with now and then an exception; i.e., an extremely heavy load with low speed, a high speed with a comparatively light load, or a small, thin-shelled bearing built out of all proportion to the load and to the speed. While one or two grades might generally give satisfaction, economy would be better served by selecting a grade best suited to one of these three or to the special conditions. Because a man is getting what he considers good service out of his 16c., 20c., or 25c. metal, it is no assurance that for 30c. per lb. he might not get double the service, or that for 14c. he might not get the same service.

Sometimes the mistake is made, in small thin bearings, of making too large oil holes and deep grooves in various directions from the oil holes. This skeletonizes and weakens the bushing. These grooves occasionally extend through half the thickness of the lining, and under constant vibration or jar, the bushings crack. The remedy is thicker linings or bushings, or else sufficient tin added to the babbitt to make it tough enough to withstand this condition. Some wash the backing against which the metal is to be poured with the ordinary plumber soldering solution so that the babbitt is soldered fast to the box or backing.

If the metal pours sluggishly, the trouble may be looked for either in the temperature being too low, or the metal containing too much copper or zinc. The increased use of smeltered or dross products and antimonial lead containing impurities in considerable quantities frequently causes this trouble.

Assuming that the metal is made right, and of the right materials, then the important features to be observed are that the right grade is selected for the condition to be met; that it is handled properly in babbitting; and that as many as possible of the conditions that tend to destroy the babbitt lining are removed.

Editorials

What Are You Working For?

Ask anyone what the difference is between a profession and a trade, and the answer will almost certainly be one relating to the character of the work. Probably the law, the ministry, or medicine will be mentioned as examples of professions, and carpentry, masonry, tailoring, farming or any other of a number of callings, as trades. We submit that the real distinction between a profession and a trade is the spirit in which it is usually followed. Viewed in this light, your vocation is the one or the other according to whether you engage in it for what you put in it, or what you get out of it. In other words, whether you work for the love of it, or for the money it brings.

It is contrary to human instinct to be idle. Some naturally prefer the good and live to be useful; others, evilly inclined, if useful at all, are so by compulsion—in order to live. Between these extremes are the careless or discouraged, who work only to get the means of a living.

We would not be misunderstood as meaning that, to be a professional man, one must work for nothing. Money, being the medium of exchange, must be the return to procure the necessities of life and the comforts and recreation that the normal man requires. To this extent, the financial reward is needful in any line of work. Nevertheless, the truly professional man who deserves the dignity of that classification makes his chief concern the good he can do. He is more anxious to be useful than rich.

Common acceptance of the term makes all clergymen, doctors and lawyers professional, but, more is the pity, some in their ranks forget that the mission of service is fundamental, the acquisition of wealth incidental. Just as there are these exceptions among those supposed to be of these professional classes, there are many in the humbler walks considered to belong to the trades, who care more to excel in their lines than for anything else. They have a pride in their work and will do as conscientiously whether their wages are high or low.

When the writer was a boy, an old Englishman, an expert wood-polisher, came to the house to polish the rosewood case of an old square piano. He was very enthusiastic over its beautifully matched grain. Constantly, while he worked, he talked about it and admired it and showed his pleasure in polishing it. The interesting part of this incident was the old man's philosophy on the hereafter. His idea of Heaven was a place where everyone could do the work he liked to do and he expected, he said, to go right on polishing wood, because of his fondness for it. Without question, he got a satisfaction out of the work of bringing out the beautiful grain of a piece of woodwork that was akin to that of the artist in putting a picture on a canvas. Probably no one would call wood polishing a profession, but this man had the real professional spirit.

All of this leads up to the fact and perhaps explains why engineering is coming to be—yes, has become a profession. Time was when there were many engineers who went about their work more or less perfunctorily, whose vision held little beyond the pay envelope at the end of the week. Rapidly is this race becoming extinct, even as the lines separating the technically trained from the practically trained engineers are disappearing. We have no patience with the self-considered élite who would have the steam-plant operator known as an engineman or engine runner or something else than engineer. There are many men still left in the plant who do not merit being called engineers yet, and perhaps never will, but those who have reached the stage where they can intelligently manage a plant of any size, are as much entitled to be considered engineers as any.

After all, "What's in a name?" We sense it that, whatever he is called, the man who devotes his life to a work he delights in, who strives to master the knowledge of that work so that he can perform it most effectively, who is earnestly making the most of his ability to be the best of his kind, be it ever so humble, is as much a man as the next. Whether he gets the admiration of the crowd, or is tagged with a title matters not, one thing he has, which no one man can take away from him, an inner satisfaction that he is working for a purpose and getting there. And such a man is any engineer who is making it his main effort to get the highest efficiency or the best performance out of the equipment in his care. He wastes no time in self-pity because he is not getting the salary he earns. Like as not, the lack of salary is more than made up to him in the happiness he gets out of his work, and generally the higher pay comes automatically sooner of later.

Work for the work's sake makes life worth the living.

Municipal Electric Plants

The opinion is held by many that municipal electric light and power plants are, as a rule, inefficiently operated, give inadequate service and represent a waste of the people's money. While representatives of private power interests have undoubtedly done much to spread this impression, the responsibility also rests with a few plants that have warranted such criticism. However, it would be as unfair to condemn municipal plants, as a class, by the experience of a few unsuccessful ones, as it would be to say that our system of government is a failure because dishonest politicians have discredited it in a few instances.

It should be possible to run a municipal plant as efficiently as a private plant, under like conditions of service; and we believe the majority are so run.

In fairness to the community which it serves, every municipal plant ought to be a self-supporting enterprise. That is, full allowance should be made for in-

terest on the investment, depreciation, retirement of bonds, etc., in addition to the cost of operation, the rates being fixed accordingly. If all the fixed charges were not included, those members of the community who use electricity would profit at the expense of the taxpayers who are not consumers.

There are over fifteen hundred municipal electric-light and power plants in the United States serving private consumers, and about two hundred in Canada, the number having doubled in the last ten years. This growth alone furnishes a strong argument in their favor. In many cases these plants, by furnishing competition, have cut in two the rates formerly paid to private power companies, and still have been able to show a substantial surplus at the end of the year, after deducting all charges. Unfortunately, too little publicity has been given to these cases.

We hope to be able, with the coöperation of municipal plant managements, to compile data on the total cost of production in a large number of these installations. If a sufficient number respond, the results will be classified according to the size of plant, type of equipment and character of service. Published in this form, the information would prove a valuable reference, as it would enable the engineer of any plant to compare his own results with those of other plants operating under similar conditions.

A Plea for Higher Settings

At a meeting of engineers recently, the disadvantages of small furnace volume or low settings were being discussed. One man inquired as to who started setting boilers close to the grate, and he was informed that the practice started with designers of the craft which plied the Ohio River. Whether this is true matters little, but the fact remains that the practice is all too prevalent.

Nearly everybody realizes that low settings do not favor complete combustion, but instead promote all the evils that tend to lower furnace efficiency, especially with soft coals, the consumption of which is steadily on the increase. This realization makes one wonder why so many engineers are still slaves to a custom that never had any logical application to stationary practice. Imagine how much too low are twenty-four-inch settings for even ordinary soft coal, when at the Delray station of the Detroit Edison Co., the flame of long-flame West Virginia coal strikes the top of the combustion chamber which is twenty-eight feet above the stoker. This happens at a boiler rating of 275 per cent. For complete combustion, the flame should consume itself before striking the comparatively cold heating surface.

In large central stations and railway power houses the value of large furnace volume is fully realized. Each new installation has boilers set higher and higher above the grate.

It is not so long since the water-tube boilers in the South Boston station of the Boston Elevated Rys. Co., were set eight feet above the stokers at the rear. At the time, many thought this was going to extremes and voices of disapproval were heard. New boilers that may be installed in this plant will, perhaps, be set still higher.

At the 201st Street station of the United Electric Light & Power Co., New York City, which is conceded to be one of the best examples of central-station engineering, the boilers are ten feet above the stokers at the rear. Such good results have been obtained with a horizontal-tubular boiler set seventy-six inches above the grate in a Newark, N. J. ice plant, that another boiler with like setting is being installed to meet the steam demands. In the double-furnace water-tube boiler at the Fifty-ninth St. power house of the Interborough Rapid Transit Co., the stoker at the rear of the boiler is about twelve feet below the lowest row of tubes and is more efficient than the one at the front which is located nearer the tubes.

Besides the amelioration of the smoke evil, there are other advantages of high settings which, as the writer pointed out in a recent lecture before Newark Number Three N. A. S. E., are not fully realized. To reduce heat losses due to running boilers at low rating, many engineers use fewer boilers at high rating to carry the load. When burning the fine grades of anthracite under comparatively high draft in ordinarily low settings much of the coal is carried away from the fuel bed. High settings greatly reduce this evil. Where too high ratings are not used, a high volatile and therefore usually cheap coal may be used in high settings without producing objectionable smoke.

Powdered Coal

A number of inquiries have been received lately for information regarding powdered coal as a fuel. The article on page 470 is a direct response to the evident desire for one of its kind. Interest centers in the practice mainly because of the possibility of utilizing low-grade fuels. Practical difficulties arise in the high furnace temperatures and the finding of a firebrick lining to withstand them.

The author takes up a number of the designs, many of them failures to a greater or less extent and gives reasons for their non-success. Altogther, it is an instructive résumé of the more important work today in this relatively new field, deserving the attention of readers who are following the developments that are being made in fuel engineering.

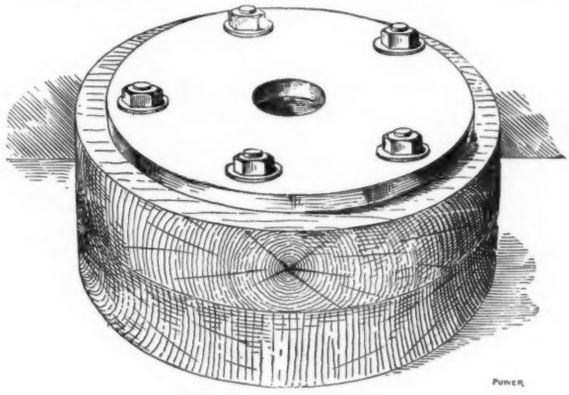
In connection with the cartoon this week, if you have not already done so, read the editorial that appeared in the March 21, issue, page 415; entitled "New York State to Economize on Coal." The reference is to the fact that New York State, like New York City, has decided to buy the coal for the plants over which it has control, under specification.

According to the estimate of Frank Shuman, of Tacony, Philadelphia, the man who has done perhaps the most in that line, the cost of an equipment to absorb energy from the sun would be about $152 per horsepower. An excellent steam plant could be put down for forty dollars, and the standard charges on the one hundred odd in excess of this would pay for coal enough to operate such a plant ten hours a day with coal at three dollars per long ton. It would appear that for the present the sun motor is in the same category as the wave motor. Energy which is now being dissipated can be conserved with either, but at a cost for investment which makes the yearly outlay greater than it would be at the present price of fuel.

Correspondence

An Emergency Pump Piston

An accident happened to the condenser pump during the busy season in a paper mill where I was the operating engineer. The plunger was broken beyond repair, and to avoid shutting down part of the mill, temporary repairs were made, as follows: We measured the exact size of the cylinder, then cut two iron disks $\frac{3}{16}$ in. thick, one



PLUNGER ASSEMBLED

inch smaller than the bore. The rod being tapered, one was drilled to fit the large end and the other the small end of the taper. Then two 1½-in. planks were spiked together, and with a keyhole saw sawed out to a plunger $\frac{7}{16}$ in. smaller than the bore of the pump to allow for the wood swelling. After assembling as shown and putting in place, it held a 20-in. vacuum for about one hour, then gradually increased to 23 in., which was maintained for two weeks, until the new parts were received.

J. B. BEDORE.

Crivitz, Wis.

Undercutting Commutator Mica

A 15-hp. direct-current motor developed serious sparking at the brushes. It would run satisfactorily for some time, then the commutator would begin to turn black, and the brushes spark and heat to an alarming degree. I tried graphite brushes and boiling the carbon brushes in paraffin, but without success. The armature was removed and placed in a lathe three times to turn down the commutator, but the same trouble appeared after about three months each time.

The last time the armature was removed I decided to undercut the mica. A tool was made a little narrower than the width of the mica, and placed in position. The armature was turned in the lathe until a slot was opposite the tool and then the tool carriage was moved by hand parallel to the commutator, beginning at the outside and working toward the armature coils. After a trip across the commutator the tool was moved back, the armature turned in the lathe until the next slot was opposite the tool and the operation repeated.

In this manner about 156 micas were undercut $\frac{1}{64}$ in. in three-quarters of an hour. When finished, the commutator was polished and put in place. The result was gratifying, the motor running better than it ever did.

I can see no reason why this could not be applied to large motors or dynamos where it would be out of the question to remove the armature. A tool carriage could be fastened to the frame of the machine and operated in the same manner as when in the lathe. The only difficulty might be the inability to move the armature so that a mica would come to rest opposite the travel of the tool.

LA RUE H. STARK.

Delavan, Wis.

Magnesia vs. Lime-Mortar Covering

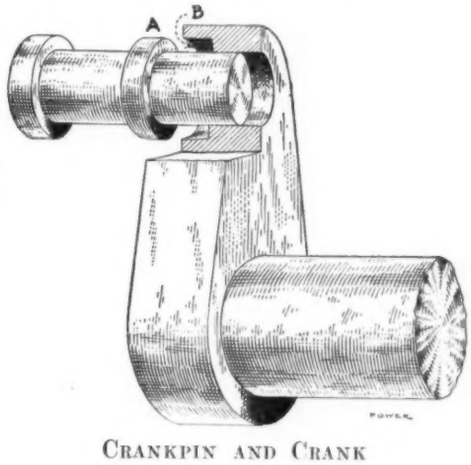
The writer has found magnesia preferable to lime mortar for covering the brickwork on the tops of boilers. Scrape the bricks clean, and apply a first coat of 85 per cent. magnesia, ⅛ in. thick, mixed as a thin grout. When the first application has become thoroughly dry, apply with a trowel a second coat ½ in. thick, mixed to a consistency of thick mortar. The surface will become firm and will bear walking on.

WILLIAM PLAISTED.

Redondo Beach, Calif.

Crankpin Break

A crankpin brass on a twin-cylinder gas engine suddenly got hot without any perceptible provocation. The engine was shut down and an examination showed that the pin was about half an inch out of the disk. On closer examination it was found that the back end of the pin had



CRANKPIN AND CRANK

not moved, making it plain that the pin was broken in the disk. This pin had given considerable trouble some time before and it was suspected that it was working in the disk, but this could not be detected.

The old pin was removed and a new one turned down

to about the size of the old one. Then the hole in the disk was calipered and found to be in bad shape, but as the nearest portable boring bar was 18 miles away and the engine was needed badly, it was decided to risk putting the new pin in the old hole. Accordingly, the old hole was scraped and filed as smooth as practicable, and the pin finished to what was apparently a good driving fit. The disk was then heated until it would melt solder in the hole. A ram was made from some old shafting suspended on a rope, and a piece of babbitt metal was fastened on the end of a rod to hold over the face of the pin while ramming.

When all was ready, the pin was started in and the ram brought into action. All went well until the pin lacked only about three-fourths of an inch of being home, and there it stuck. No amount of ramming would induce it to go farther; nor could it be backed when the ram was applied to the other end.

The pin was made with a collar *A*, to fit into the counterbore *B*, as shown. We at last decided to cut away the collar, and use the pin as it was until we could get another pin.

A sledge and cold chisel were used to cut the ring down to almost finished size, and then the finished cut was made with the pin-turning device that had been used to true up the old pin. After the pin was smoothed up nicely, the counterbore was filled with babbitt metal flush with the face of the disk. The brass was then put on with about two thicknesses of tin between it and the disk and the space between the brass and the end ring on the pin was filled with babbitt metal.

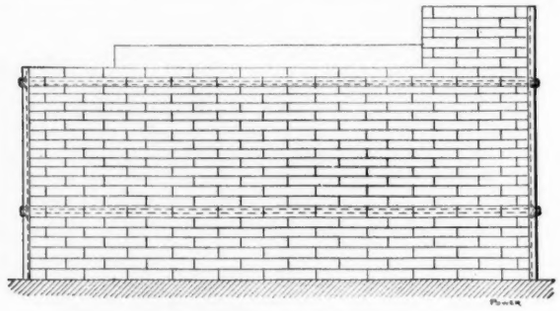
This completed the job. After adjusting the new brass and connecting up, the engine was started and the load put on. The brass ran warm for a day or two, but it is now running cool under full load.

EARL PAGETT.

Coffeyville, Kan.

Preventing Cracks in a Boiler Setting

But one side wall of a boiler setting is exposed in my plant, and keeping it in good repair has proved both a difficult and expensive task. When this battery of boilers was originally set, it was allowed to stand for several weeks before fires were built, and the masonry had ample



REINFORCED BOILER SETTING

time to dry. Soon after the boiler was put into service, however, cracks appeared in this side wall. About four feet of it was taken down and rebuilt, but cracks soon appeared in the same places. The work was repeated but proved to give no better results than before.

The rods holding the cast-iron fronts in place were about four feet long, with about six inches at the end, turned at right angles for an anchor. There were no supports at the rear of the wall. On one occasion when the upper part of this wall was taken down for repairs, the short rod was removed and a long one substituted, extending the length of the wall, with a large washer, and a nut at the rear. This was an improvement, but it did not wholly prevent the wall from cracking.

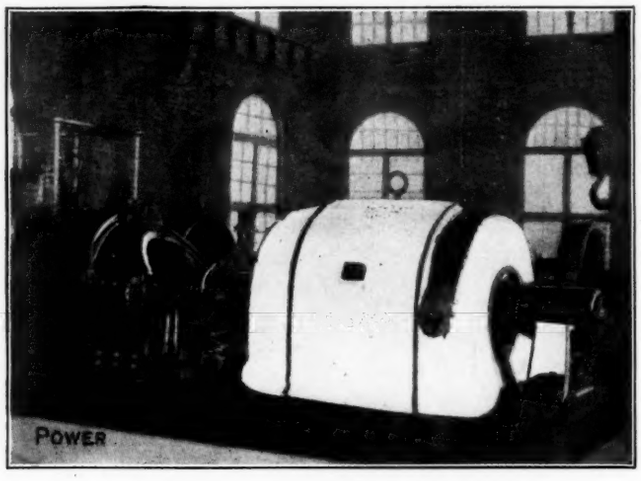
Later on, this wall was taken down to within 2 ft. of the boiler-room floor, and securing two pieces of 8-in. channel iron they were set up, one at each end, as illustrated. Holes were chiseled out of the brick floor to receive the lower ends of these channel irons, and they were cemented in place. Two ⅞-in. rods were threaded at both ends to receive nuts and were put in place to act like through braces in boiler construction. They were built into the wall, and as the mortar dried and shrunk the nuts were tightened. This was done nearly two years ago, and no cracks have yet appeared.

W. H. WAKEMAN.

New Haven, Conn.

Frost-Covered Generator

The turbo-generator shown is a 1000-kw. machine, and the windings are cooled by air drawn from outside the power house. At the time the photograph was taken the outside temperature was 26 deg. below zero and the gen-



GENERATOR COVERED WITH FROST

erator was covered with frost, in some places ⅛ in. thick. The dark spot is where the frost started to melt off after a full load for two hours.

F. E. ALBRECHT.

Lisbon, Ohio.

Graphite in Boilers

A. G. James' experience with badly corroded boilers due, in his opinion, to the use of graphite, does not tally with my experience. We use artesian-well water containing a large percentage of lime. I found the three boilers scaled badly and tried different compounds, but obtained the best results by first painting all inner surfaces with graphite, then feeding it daily as directed. The boilers are now thoroughly clean and the inspector has raised the

pressure limit 30 lb., on two of them. Mr. James says the corrosion was found at the annual inspection. I have found it good practice to give boilers a thorough internal inspection at least once every three months. It does not look as if all of the blame can be placed on either the "Young College Graduate" or the graphite.

CHARLES V. BECKER.

East View, N. Y.

Lubricating Engine Bearings

Mr. Crockett's views on lubricating engine bearings, in the Jan. 20 issue, are held by many good mechanics, but I would like to know if he, or any other man, can present

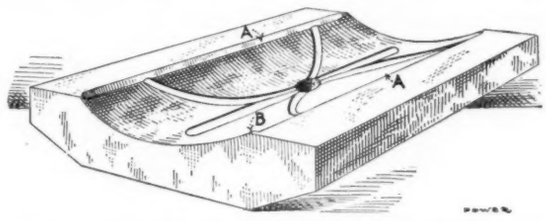


FIG. 1. GROOVES IN BOTTOM BEARING SHELL

a logical reason for cutting such grooves in journal shells as he describes.

If a journal runs hot it is taken apart and scraped to a fit, and if it happens to be without grooves, deep ones are cut. If the journal runs cool after it is again put in service, the newly cut grooves get the credit, instead of the newly dressed bearing surfaces, which are more likely to have improved conditions. If the bearing still runs hot, no one blames the oil grooves.

The first journal I put up without oil grooves was on a belt-driven rotary pump with a 4-in. shaft. Three months later the chief had the caps taken off to facilitate removing a gear. There was one slot cut in the cap lengthwise, but none in the bottom shell. He called my attention to the omission and said things not fit for publication. Although he was a capable man, he believed that all bearings should be grooved, and the fact that the bearings had run cool for a month made no difference to him.

Referring to Mr. Crockett's sketch, if oil were introduced to the top of the grooves in his Fig. 2, if these grooves were connected with those in Fig. 4, and the latter grooves connected with the bottom of the opposite side quarter box, it is possible that oil would flow through them and supply oil to the shaft at all parts of the bearing. With oil fed onto the shaft, and allowing that the grooves in Fig. 2 are always kept full, with steam working in the crank end of the cylinder, the shaft will be pulled back the amount of the clearance between the shaft and the quarter boxes. This should not be any more than the thickness of an oil film or the shaft will pound.

As the shaft revolves it carries a film with it. Suppose this film is heavy enough to fill the groove shown in Fig. 4, is there any chance that the shaft will pick up oil if the shaft is well worn in the bearing, with a pressure of at least 100 lb. to the square inch? I think not, and if this same film is depended on to fill the grooves shown in his Fig. 3, I will have to be shown. If the shaft is well bedded in the box I would turn the engine one revolution to see where the shaft bearing comes and make it uniform from one end of the box to the other.

The edge *A* of the bottom box, Fig. 1, should be cut away at an angle of 45 deg. with the face *B* to within ⅜ in. of the ends of the boxes. The oil will carry around just as well as if the babbitt were grooved and the area that would have been used for them is left for its real purpose.

There are engines which are overloaded and the bearings heat up no matter how carefully they are fitted. If these bearings are watched before they begin to heat, it will be found that the shaft will come up dry, because the pressure is so great that the oil is forced out from between the shaft and the bearing.

The surest way to oil such bearings is to automatially pump oil into the bottom shell. Oil pumped into the center hole will be forced out into the bearing, due to the pressure being greater than that of the shaft in the bearing. Here I approve of an oil groove, because I can see that it is for distributing oil the length of the bearing, as also do the shelves at *A*.

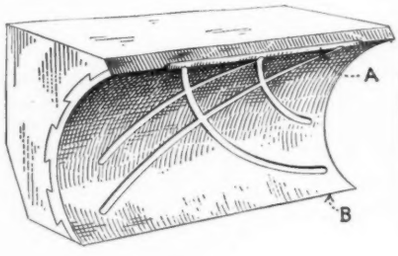


FIG. 2

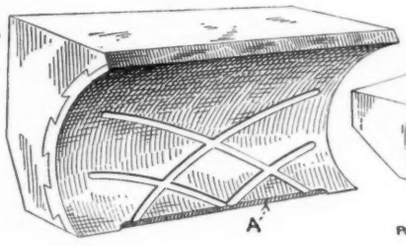


FIG. 3

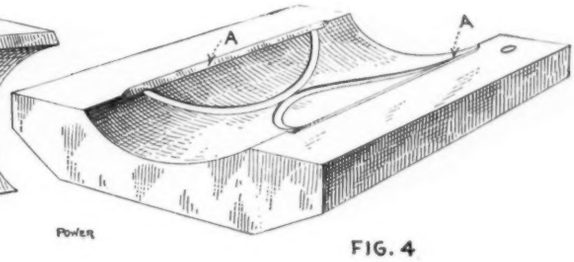


FIG. 4

MR. CROCKETT'S METHOD OF GROOVING BEARING BOXES

As for oil holes in crankpin shells, hardly anyone now uses them in center-oiled pins. A flat spot ½x½-in. should be filed over the oil hole, and grooves of $\frac{1}{16}$-in. radius cut in the pin, as shown at *C*, Fig. 5, the grooves running opposite to that of the rotation of the pin from the hole.

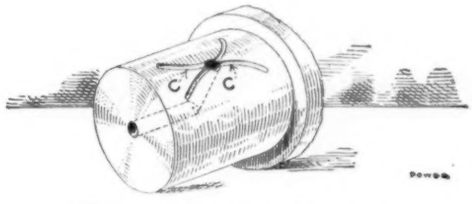


FIG. 5. GROOVED CRANKPIN

I have found can oiling wasteful, dirty and dangerous around a Corliss gear; a grease cup is cheaper and more satisfactory.

S. H. FARNSWORTH.

Chicago, Ill.

Converting Generator into a Motor

The owners of a machine shop required an additional motor to drive some new machines. A compound generator was found at a second-hand dealer's, which he assured them would be large enough to do the work, and could be readily changed to a motor. It was accordingly purchased and installed. The field rheostat was retained and a water barrel provided for starting. The electrician made what he considered the proper connections, and felt assured that they were right when the motor ran properly without sparking or heating with no load.

The moment that load was put on, the brushes sparked badly, the motor emitted groans, came to a standstill and then immediately speeded up in the opposite direction, to the great mystification of all present.

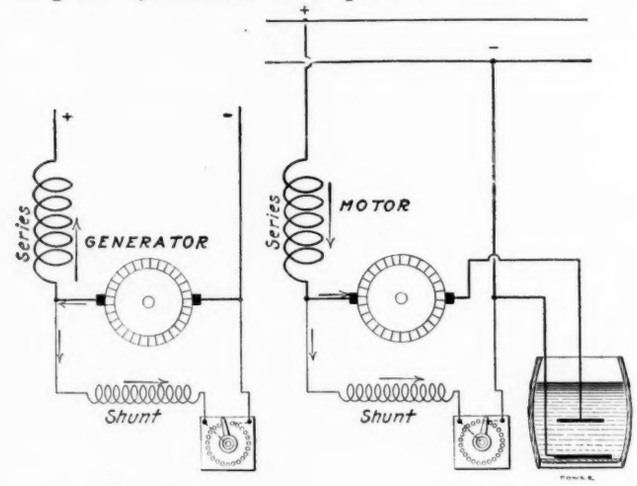


FIG. 1 FIG. 2

DIAGRAM OF CONNECTIONS WITH MACHINE CONNECTED AS GENERATOR AND AS MOTOR

On questioning the man who made the connections, it was found that in the first place, the connections were as shown in Fig. 1. When it was decided to run the machine as a motor, he made the connections, as shown in Fig. 2, neglecting to reverse the series-field connection, which was necessary as will be readily perceived from a study of the diagrams.

Fig. 1 shows the connections when used as a generator. If the direction of current flow is noted and arrows drawn and then compared with Fig. 2, it will be seen that the current in the series winding does not flow in the same direction in both cases. This accounted for the trouble. With the light load the field was entirely due to the shunt winding. Putting on the load increased the current in the series field sufficiently to overcome the effect of the shunt field and caused the motor to reverse. Reversing the series field remedied the matter, as was proved by running the motor with and without load without any further trouble.

As differentially wound motors are not much used, a simple method for determining whether a compound motor is properly connected when no directions are at hand, is to connect it in the usual way, then open the shunt-field circuit, start the motor with the series field alone and note the direction of rotation. Care should be taken not to allow the motor to reach too high a speed, and tests should be made without load. Start up again with both fields connected and no load. If the motor continues to run in the same direction as it did with the series field alone, it is properly connected. If not, one of the field connections must be changed until the armature revolves in the same direction with either field connected.

Another source of trouble after overcoming some of the above obstacles is the question of changing the direction of rotation.

Through ignorance or inadvertence, the shunt field alone will often be reversed to accomplish this, which it apparently does, as the motor will reverse until full load is applied, when the trouble occurs.

The safest and quickest way is to reverse the armature connections, or better still if feasible, move the brush rocker through an angle of 180 deg. in the case of a bipolar machine; 90 deg. in a four-pole, and 60 deg. in a six-pole machine, to accomplish the same result.

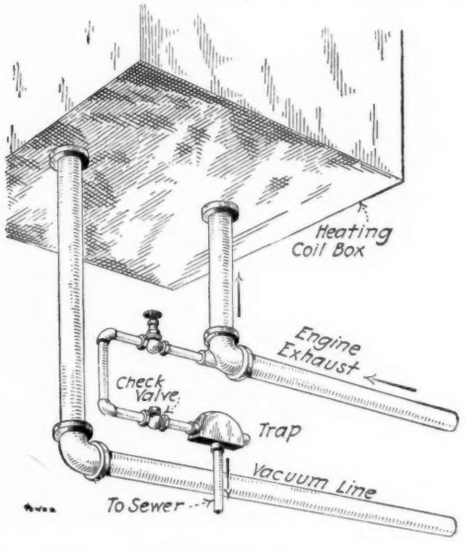
P. JUSTUS.

Cleveland, Ohio.

Home-Made Oil Separator

We had long been troubled with cylinder oil from an engine driving a fan and exhausting into the heating coils. The oil passed through the coils and the return line, and it became serious when it got into the boilers; besides, it formed an undesirable insulation on the inside of the coils.

The plan hinted at in the sketch eliminated most of our trouble. A loop or drop was made in the exhaust line and a home-made trap was attached at the lowest



OIL DRAIN

point. As there was a vacuum in the exhaust line at certain times, a check valve was used to exclude air; at others there was a back pressure, so a thermostatic trap such as one sees on radiators was added.

The device is automatic, requires no attention and discharges oil and water into an open pit almost constantly.

EDWARD T. BINNS.

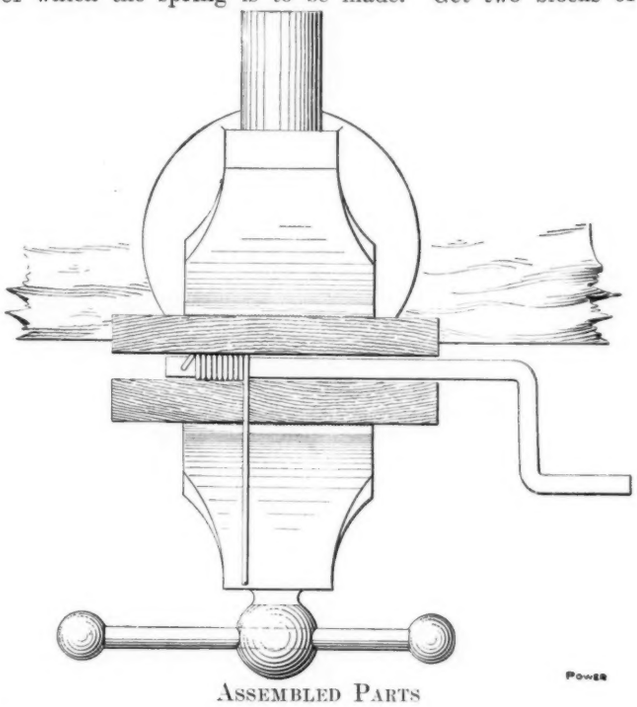
Philadelphia, Penn.

[Since taking out the oil seems incidental rather than functional, this could more properly be termed a thermostatic drain.—EDITOR.]

Making a Coiled Spring

This may be old to some but I only happened across it lately, and wish I had known it long ago, as it would have saved time and money.

Take a rod somewhat smaller than the size of the spring desired. Bend a handle on one end and punch or drill a hole through the other end, the size of the wire of which the spring is to be made. Get two blocks of



ASSEMBLED PARTS

wood, preferably hard wood, and put them in a vise with the rod between them, and clamp all together firmly. The hole should be a little past the center, lengthwise of the blocks, and in such a position that the wire can be thrust into it. Put the wire through the hole, just even with the other side of the rod, and then wind the wire on the rod by turning the handle. If an open spring is desired start the wire winding the desired distance apart. If a close spring is desired start it winding close. When it is nicely started it will make a groove for itself and all that is required is to turn the handle. This will make a first-class spring out of quite large wire.

Winnipeg, Man., Canada. A. W. CARD.

Recipe for Metallic Packing

A good cheap metallic packing suitable for nonsuperheated steam, air, gas and ammonia may be made as follows:

Melt in a clean ladle the following, which will be sufficient for slightly over 8 lb. of packing:

Lead	5 lb.	8.88 oz.
Antimony	1 lb.	0.62 oz.
Tin		6.25 oz.
Bismuth		0.25 oz.

When melted run through a fairly fine sieve about $\frac{1}{16}$ in. mesh held 9 or 10 in. over the surface of a bucket of clean, cold water, this will be found to have split the metal up into small, rough parts of approximately equal size; of course, the metal will be well mixed in the ladle before pouring.

After the metal has been taken from the water, dry it and give it a bath in 14 oz. of the best paraffin wax melted in an open top pan with 10.5 oz. of best lubricating graphite.

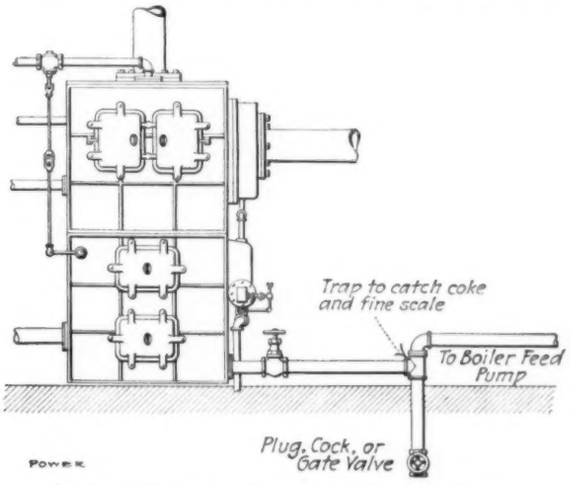
In packing a gland, first put in a ring of some good, soft packing, then ram the stuffing-box full of the metallic packing and drive it up with a piece of hard wood, finishing off with a turn of soft packing. This packing takes about a day's run to bed up when it will give satisfaction, especially on Corliss valve spindles.

E. R. PEARCE.

Rochdale, England.

Settling Chamber for Filter Coke

A number of the open heaters now on the market use coke as the filtering medium. This often gives trouble by being carried through to the feed pump and lodging under the valves. The sketch shows a way of piping the



DROP-LEG TO CATCH COKE FROM FILTER

feed pump to overcome this trouble, the coke falling into the drop leg before it can be carried to the suction chamber.

CHARLES FENWICK.

Humboldt, Sask., Can.

[The area of the pipe near the drop leg and of the pipe of which the drop leg is made should be large enough to reduce the velocity of the water through the coke chamber.—EDITOR.]

An Oversight

Among the machines in a plant where I was once employed, was a small motor-generator set. In order to make repairs to the commutator, the bearing, of the single-ring oiler type, was removed from the generator end. After the repairs had been made and the machine reassembled, it was started up about 9 a.m. At 3 p.m. this bearing was unusually warm, and in an hour more the temperature had risen considerably.

An investigation showed that the oil ring had been hung up out of the slot in the top box to avoid crushing while putting the bearing together, and had been left there. A stick was inserted through the oil-well cover and the ring pushed down into place; in half an hour the temperature of the bearing was again normal.

JOHN A. LEVY.

Greenfield, Mass.

Engineers' Study Course

Elementary Mechanics--III

Answers to Last Week's Questions

6. The resultant of two or more forces is a single force that will produce the same effect on a body as the combined effect of the other forces. The resultant can be found first, by a graphical solution; second, by the use of the general formula for the resultant of two forces; and, third, by resolving the forces into their horizontal and vertical components and using the resultant components as two forces acting at 90 deg. to one another.

7. To solve this problem the student must bear in mind that when three forces act on a body any one force may be considered as the resultant of the other two forces. The pressure exerted by the steam is transmitted by the piston to the piston rod and thence to the connecting-rod, through the crosshead. The connecting-rod exerts a reaction on the crosshead, which produces a pressure between the crosshead and the guides, and this pressure is at right angles to the direction of motion of the crosshead. The thrust in the connecting-rod can then be considered as the resultant of the reaction exerted by the guide on the crosshead, and the pressure of the steam on the piston rod. In Fig. 10, let the length of the line OA represent the load P on the piston equal to 6000 lb. Let

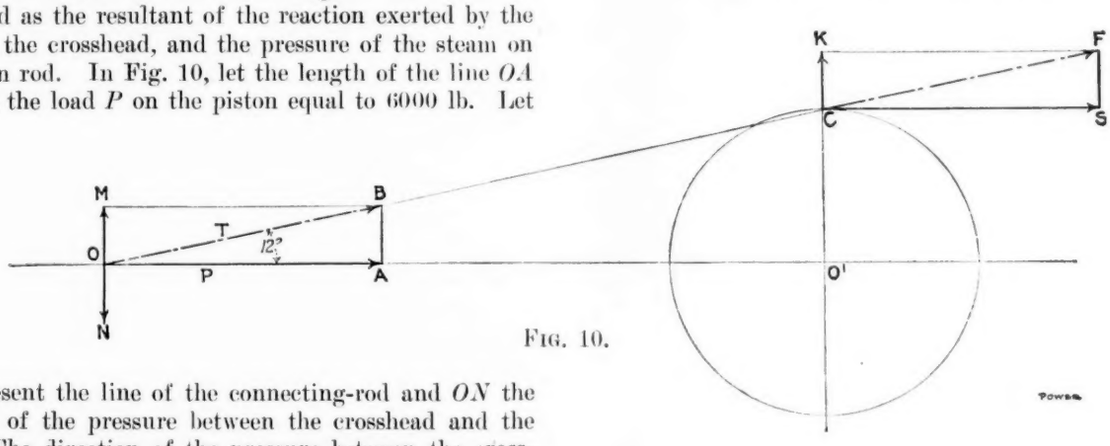


FIG. 10.

OB represent the line of the connecting-rod and ON the direction of the pressure between the crosshead and the guide. The direction of the pressure between the crosshead and the guide is given by ON, but OM represents the reaction offered by the guide. Construct the parallelogram $OABMO$. The diagonal OB will give the desired thrust in the connecting-rod, and its value can be found from the right-angled triangle

$OABO$. As $\cos 12 \text{ deg.} = \dfrac{OA}{OB}$

$$OB = \frac{OA}{\cos 12^\circ} = \frac{6000}{0.978} = 6140 \text{ lb.}$$

This problem demonstrates the fact that when the lines of action of three forces are known and only the value of one force is given, the values of the other two can readily be found by applying the parallelogram law.

8. The pressure between the crosshead and the guides is represented by the line ON which by construction is equal to AB, which in turn is the altitude of the triangle $OABO$. In the triangle $OABO$, $\tan 12^\circ = \dfrac{AB}{OA}$.

Therefore, $AB = OA \tan 12^\circ = 129.6$ lb.

9. When a force acts on a body its point of application can be assumed anywhere in the line of action of the force. Consider the thrust in the connecting-rod transferred from the point O to the point C, and let its value be represented by the length of the line CF (Fig. 10). As explained in Lesson I, any force can be resolved into components along any desired lines. Hence, resolve the force CF into two components, one at right angles to the line of the crank $O'C$, and the other parallel to the crank. To do this draw the line CS at right angles to $O'C$ and extend the line of the crank to K. Draw the parallelogram $CKFSC$. The length of the line CS will then represent the force tending to rotate the crankpin, and CK will represent the force which, at this instant, produces a tension in the crank.

By construction the angle FCS must equal 12 deg., since CF is parallel to OB, and CS is parallel to OO'. Also $CF = OB = 6140$ lb.

$$CS = CF \cos 12^\circ = 6000 \text{ lb.}$$

and

$$FS = CF \sin 12^\circ = 129.6 \text{ lb.}$$

10. First make a neat drawing of all the forces acting, representing their magnitudes by the length of the lines (to a given scale) and showing their direction by laying off the necessary angles. Thus in Fig. 11 draw the line $OA = 50$ lb.; the line OB (making an angle of 30 deg. with the horizontal) $= 40$ lb.; the line OC (making an angle of 60 deg. with the horizontal) $= 60$ lb.; and the line OD (making an angle of 120 deg. with the horizontal) $= 45$ lb. On the forces P_1 and P_2 construct the parallelogram of forces giving the resultant R; in like manner combine R and P_3, giving the resultant R_1; and finally combine R_1 and P_4, giving the resultant R_2. By careful measurement R_2 is found to equal 143.5 lb.

The resultant might be found by resolving all the forces into their horizontal and vertical components.

Thus the sum of the horizontal components is

$$H = 50 + 40 \cos 30^\circ + 60 \cos 60^\circ + 45 \cos 120^\circ$$
$$= 50 + (40 \times 0.866) + (60 \times 0.5) - (45 \times 0.5)$$
$$= 92.14$$

The sum of the vertical components is

$V = 0 + 40\ sin\ 30° + 60\ sin\ 60° + 45\ sin\ 120°$
$= 0 + (40 \times 0.5) + (60 \times 0.866) + (45 \times 0.866)$
$= 110.9$

but $R^2 = H^2 + V^2$

Therefore $R^2 = 92.14^2 + 110.9^2 = 20\,795$

$R = 144.2\ lb.$

The value of R is a trifle higher than that found from the graphical solution, but is more accurate.

The direction of the resultant force R_2 is found from the equation, $tan\ a = \frac{V}{H} = \frac{110.9}{92.14} = 1.204$

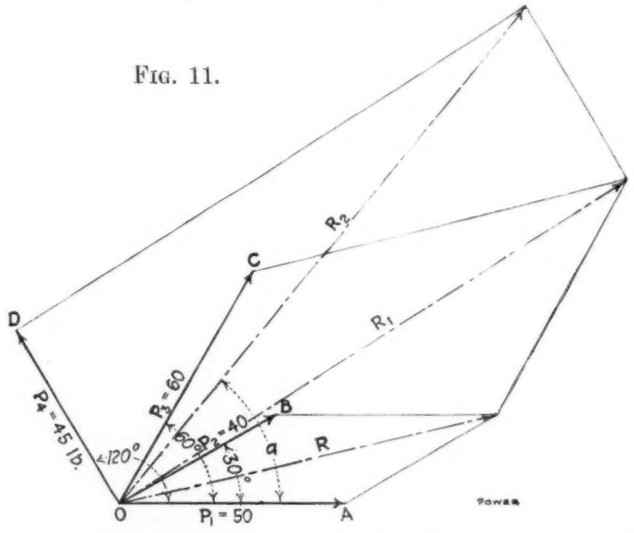
$a = 50°, 20'$

Therefore, the resultant force equals 144 lb. and makes an angle of 50 deg., 20 min. with the horizontal.

Free Body

In the problem just solved the student has doubtless noted that no reference was made to the size or shape of the various parts of the steam engine, but only the forces exerted by the various parts were considered. When all the parts of a machine, structure, or body are replaced by the corresponding forces, or reactions, exerted by the parts, the whole is spoken of as a *free body*. In the problem on the engine the wristpin at the point O receives the thrust of the connecting-rod and also the thrust of the piston rod, yet for the solution of the problem it is easier to neglect the source of the force, or the parts

Fig. 11.



transmitting the force, and consider the forces only. Take, for example, a beam resting on two columns, and carrying several concentrated loads. From the standpoint of mechanics the beam, the form of the loads, and the nature of the columns can be neglected, so that the problem would take the form shown in Fig. 12. The reaction exerted by one column has been replaced by a single upward force R_1 at the point B; the concentrated load at D, which might be the weight of a machine or another column, has been replaced by a single force W_1 acting downward; the load C has been replaced by the force W_2 and the reaction of the column A by the single force R_2 acting upward. In the solution of any problem dealing with forces, the student will find his work much simplified, if he will first analyze his problem, then isolate all forces and reactions and solve as if dealing with a free body.

Equilibrium

When any number of forces act on a body so as to produce a state of rest, or uniform motion of a body the forces are said to be in *equilibrium* or balanced. An oil can is resting on a shelf. Think of the can as a free body and what is the result? The weight of the can will be replaced by a single force acting downward, while the resistance offered by the shelf, due to its strength, will be replaced by a single force acting upward. These two forces must have the same point of application and be equal to each other but acting in opposite directions. The least number of forces that can produce equilibrium is,

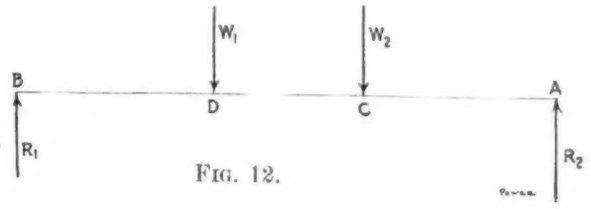


Fig. 12.

therefore, two. Hence *when two forces act on a body to produce a state of equilibrium it follows that these forces must have the same point of application and be equal in magnitude and opposite in direction.* So long as a body remains at rest it is self-evident that the forces are balanced. Suppose, however, a body is in motion—are the forces in equilibrium as before? Take, for instance, a steam engine running at a uniform rate of speed. The pressure of the steam on the piston is just sufficient to balance the load on the engine, and to take care of all friction in the bearings, pins, etc. As long as these forces are balanced the engine continues to rotate at a uniform rate of speed, and will continue to do so unless some of the forces are changed. For example, the least drop in the steam pressure will cause the forces to become unbalanced and the engine will start to slow down; or if the pressure increases the equilibrium is again destroyed and the engine will speed up. Hence the condition of equilibrium of a body, whether at rest or in a state of uniform motion, can only be changed by the addition of an extra force.

What then are some of the conditions of equilibrium for concurrent forces acting in the same plane? Suppose all the forces acting on the body are resolved into their horizontal and vertical components. It must be evident that if there is to be equilibrium of a body the *resultant of all the forces acting on the body must equal zero*, or, put in the form of an equation,

$$R = O \qquad (6)$$

For the resultant to be zero the algebraic sum of all the horizontal components must equal zero, and the algebraic sum of all the vertical components must equal zero.

Therefore, $R^2 = \Sigma H^2 + \Sigma V^2 = 0 \qquad (7)$

hence $\Sigma H = 0 \qquad (8)$

$\Sigma V = 0 \qquad (9)$

Σ stands for "summation of," or "algebraic sum of."

Study Questions

11. What is meant by the term "free body"?

12. Are the forces acting on a body at rest in equilibrium?

13. Can the forces acting on a body in motion be in equilibrium?

14. State the general conditions for equilibrium for concurrent forces.

15. Make a sketch showing the crankshaft of a vertical side-crank engine as a free body. Assume the engine on the top dead center.

Power Production in the United Kingdom*

By EDWARD G. HILLER

The great bulk of the power in the United Kingdom is generated by steam boilers and steam engines of various kinds, as shown in Fig. 3. It is estimated that there are in the United Kingdom 160,000 steam-generating boilers, apart from railway locomotives, of which in 1911 there were 22,874.

As the industries of the country steadily increase in output and in power requirements, so the total power developed tends to increase. This naturally would call for an increased number of steam boilers, but this tendency is somewhat checked as part of the increase of power is provided by gas engines, oil engines, and the like; also, that new boilers when put down are generally of greater power than the old ones, so that a less number do the same amount of work. Further, by increased economies in the utilization of fuel, a smaller number will do the same work. On the whole, therefore, even with an increasing industrial output the tendency to increase in the total number of boilers will be materially checked.

In Fig. 1 the figures give the approximate proportions in which the boilers of the different classes exist in the country, but do not show the horsepower rating of the different types. They also afford some indication of the changes which are taking place owing to various causes.

The Lancashire boiler was the standard type up to a few years ago, but now in the larger electric-power stations, water-tube boilers are more generally adopted.

The Cornish boiler is generally used only for such industries where it is desired to have an internally fired boiler of less power than a Lancashire boiler. The general proportion tends to decrease.

In recent years the water-tube type has shown more life and movement in production and variety of types than other boilers on land, although on its introduction in Great Britain about 30 years ago it was regarded as undesirable.

It is much easier to design a water-tube boiler for high pressures, such as 200 or 250 lb. per sq.in., than to make a satisfactory Lancashire boiler for these pressures. Therefore movements toward high pressures tend to favor the water-tube boiler.

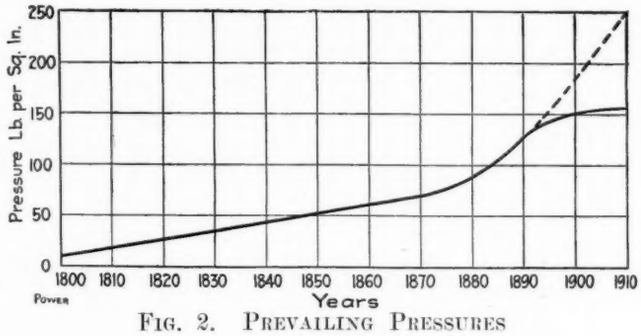


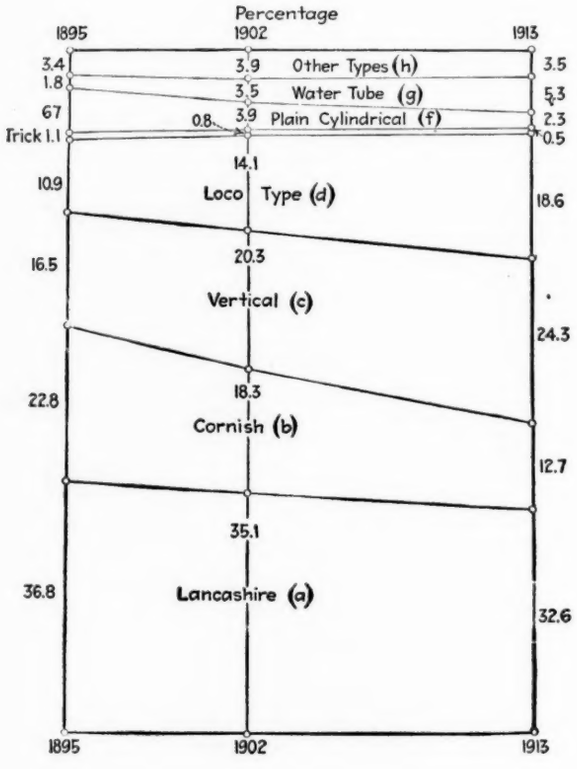
FIG. 2. PREVAILING PRESSURES

In 1890 the capacity of an ordinary water-tube boiler was about equal to one Lancashire boiler, with an evaporation of 5000 or 6000 lb. of water per hour, whereas at the present time in various power stations new water-tube boilers are put down equal to an evaporation of four or five Lancashire boilers evaporating, say 25,000 to 30,000 lb. of water per hour.

The figures show an increasing proportion in point of numbers, and if they referred to growth of capacity, the increase shown would be considerably more, as many of the new water-tube boilers which count only as one boiler have rated evaporations equal to several Lancashire boilers.

The locomotive boiler is one of the most remarkable types in use. Probably if it were today presented for the first time, nearly all engineers of experience would predict that owing to its complexity and rigidity it could not possibly work satisfactorily. It has, however, given satisfaction in various branches of industry and has become practically the standard type of movable boiler on land. At first designed for railways, it continues practically in the same general form as was settled upon many years ago.

The plain cylindrical-type boiler is a rapidly decreasing one. It was one of the earliest, as it is one of the simplest forms of steam boiler. Generally, its disadvantage is that it is short of heating surface, and the external shell, being heated, is subject to various kinds of defects arising from differences of expansion, contraction and the like. To over-



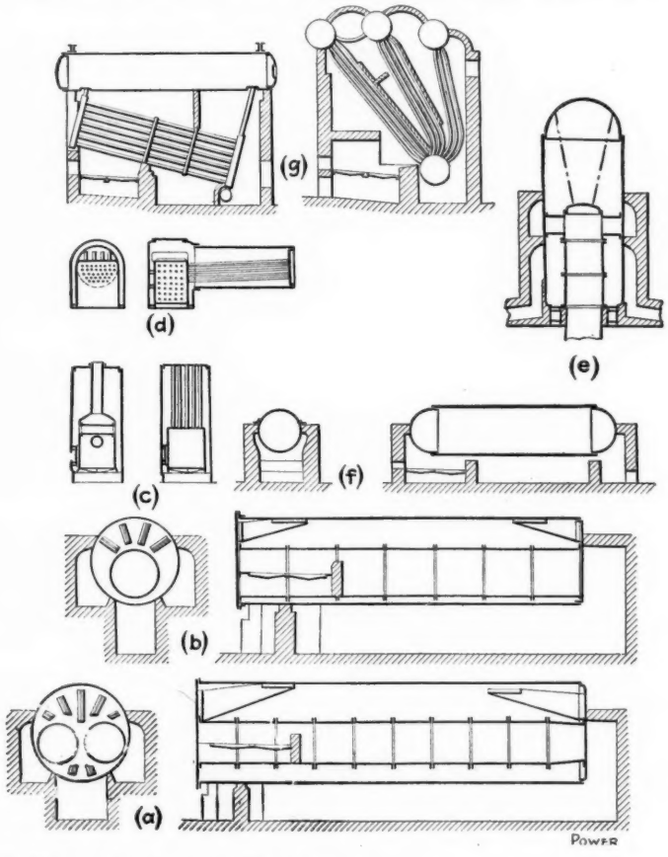


FIG. 1. DIVISIONS IN NUMBERS AMONG TYPES

*Abstract of paper read before the Manchester Association of Engineers, Jan. 24, 1914.

come the deficiency of heating surface in the old days, increased length was adopted, and with boilers 5 ft. 6 in. in diameter, lengths of 50 to 70 ft. were reached. This great length led to defects and explosions owing to rips at the ring seams. The general realization of the insecurity of this type in the long form has made it obsolete, and few new boilers of this description are being made.

It is notable that the externally fired cylindrical multitubular boiler, the standard low-pressure boiler of the United States, has never obtained any substantial footing in Great Britain. It is a cheap form of steam generator to produce, but it subject to serious risks in working; consequently in

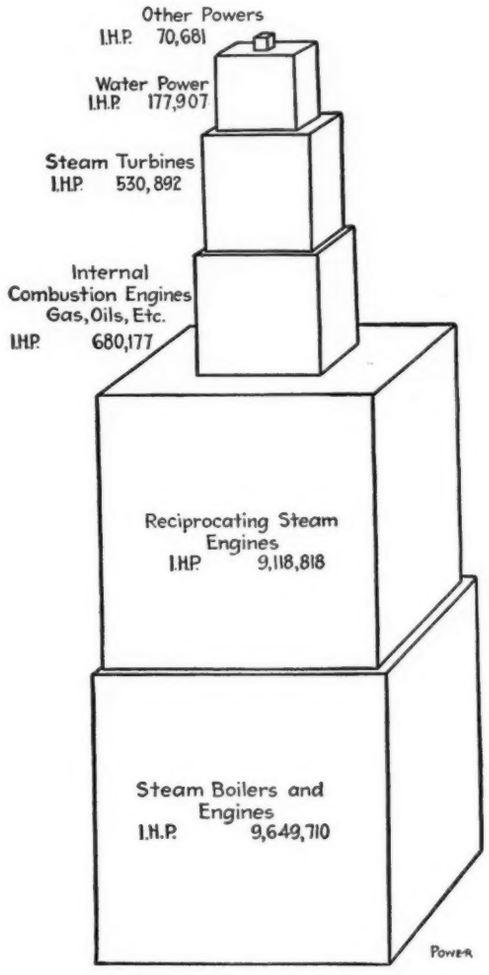


FIG. 3. DIVISIONS OF POWER

the United Kingdom the influence of the boiler-insurance companies has been against this particular type, and has checked or prevented its wide introduction.

The lower line in Fig. 2 indicates approximately the steam pressures generally adopted in the case of Lancashire boilers for textile factories, etc. From about 1880 is to be dated the practical introduction of the modern water-tube boiler, and the upper dotted line in Fig. 2 may be taken as broadly indicating the trend of the maximum pressures in the case of water-tube boilers, as employed for electric-power stations.

⁂

Utilizing Gas-Engine Rejected Heat—The firm of John Cockerill, in Seraing, has made tests to determine the worth of the rejected heat from a gas engine for developing steam for use in a turbine. It was found that practically two pounds of steam of 120 lb. pressure could be made from the heat rejected by the engine for each horsepower-hour developed, and this being used in a turbine requiring 14.3 lb. of steam per kilowatt-hour made a gain of 13½ per cent. in the power developed. The gas engine used in the experiment developed 1250 horsepower. Calculation shows that in an electric station with four gas-engine-driven units of 2500 hp. each the cost of the waste heat and turbine installation would be saved in less than two years.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Last week we wrote a weather fling,
Bewailed the Winter's cold and sting,
And longed for balmy, sunny Spring,
"By gosh," we said; "ain't no such thing!"

Now, we're sorry we bawled out Spring
For Winter's now a busted thing,
And sky and earth chuck full of Spring,
It's tough what luck a week will bring.

⁂

They had a mysterious boiler explosion at William Shakespeare, Jr.'s, plant in Kalamazoo recently. Perhaps an enemy hath done this thing. The elder William said some pretty stiff things in his time, but we can't seem to recall that he mentioned Kalamazoo.

⁂

Well, well! Here's Willie Weller who, while fixing a carbon in a lamp on a Pittsburgh street, was overcome by sleep. His spurs were in the pole, his body in the belt. The fire company tenderly took him down and started for the hospital. Then Willie Weller woke and went back to his pole. Willie ought to watch his "lamps."

⁂

Welcome to our midst the brand new engineer—the "rural life engineer!" This feller "goes into rural communities, analyzes their life, pursuits, pleasures and needs; cures defects and builds character by living among the people." What's your home town, feller, we'd like to know you—and ask you how you're making out?

⁂

Our consul at Shanghai suggests that Americans help to establish Western dental schools in China, "thus mitigating much suffering." As a dentist has a hard time trying to be popular, he'd better steer clear of that "painless" brand, and break it to 'em easy.

⁂

This from one we invited to contribute. "As for compensation, we need not worry much; for if I write what I like, on a subject I like to write about, it will not make much difference what the rate of payment is. In any case, whatever I may say will probably need a great deal of blue-penciling and boiling down to be available in the space you can give to such subjects."

This contributor looks at these two questions the way the editor thinks he should. Like Abou-ben-Adhem, "May his tribe increase!"

⁂

A West Virginia reader says: "Ask Billy Spills what he thinks of an engineer who has run a 400-hp. engine for three years and says he doesn't believe in indicators."

Years ago, we were mixed up with the law for saying just what we thought in cold type. We pass.

⁂

There's nothing like knowing what the chap called the pishological moment. Two locomoteers jumped off their engine "at the first sign of the explosion," which is stated to have been when "the crown sheet blew off and the boiler busted." This is going while the going is good!

⁂

Here's a "near" explosion, clipped by friend Standley, Fort Wayne:

"While Smith Bros. were trying to thaw ice out of a pipe connected with their hay bailer, they discovered that the boiler was red hot and no water in it. It is thought that quick work in drowning the fire prevented an explosion that beyond a doubt would have resulted seriously."

Please make your own comment. You have more latitude than we have.

⁂

It's easy enough now to see why those Boston Commercial Engineers are such hearty, jovial good fellows. Their February "Bulletin" says their annual banquet is from Mar. 21 to June 13! Better let up long enough to give the "Power Show" one of your rousing boosts, boys.

The Development of the Modern Central Station

By I. E. Moultrop and W. N. Smith

On Saturday evening, Mar. 14, I. E. Moultrop, at a joint meeting of the American Society of Mechanical Engineers and the Engineers Club of Philadelphia, at the home of the latter organization, delivered a lecture prepared by himself and his assistant, W. N. Smith, in which he illustrated with lantern slides a number of the large American central stations, bringing out and commenting upon their particular features.

The development of the alternating-current system of power transmission and distribution began some twenty years ago, and about the first of the large stations to avail itself of the possibilities of the system in location at a point of convenient coal and water supply was the Bay Ridge Station of the Brooklyn Edison Co., built about 1896, and utilizing 6600-volt transmission.

THE STREET RAILWAY LOAD

A tendency to combine the street railway and lighting services has resulted in larger load factors and better conditions for both. The proportion of railway load to lighting and power load in St. Louis is about 40, in Washington about 50, and in Chicago over 50 per cent. of the total central-station output. The New York Edison Co. has lately taken over the operation of the Kingsbridge Station of the Third Avenue Ry., with about 40,000 kw. capacity.

WATER SUPPLY

The importance of the location of the station, with reference to the easy incoming and storage of the raw material, the coal, and of access to an abundant and cheap supply of water, was emphasized. If a station of the size of that of the Edison Electric Illuminating Co., of Boston, lost its condensing water source the city would have to lay a separate water main to supply it. The amount of condensing water required is equivalent to the total water supply of a large city. Numerous slides were shown illustrating the methods of coal storage and handling in various stations.

RATIO OF BOILER AND GENERATOR CAPACITY

In the L Street Station of the Boston Edison Co. there were originally installed eight 500-hp. boilers to one 5000-kw. turbine, or 1¼ kw. of turbine per boiler horsepower. As the station developed, larger sized turbines were used, and with their better steam rate and the modern practice of getting from 200 to 300 per cent. rating out of the boilers, the generator capacity of the station has been increased to 96,000 kw. with a boiler capacity of only 24,000 hp., or 4 kw. per boiler horsepower. At the Northwest Station of the Commonwealth Edison Co. in Chicago ten 580-hp. boilers are used for each 20,000-kw. turbine, giving a ratio of 3.46 kw. per boiler horsepower. At the new South Boston Station of the Boston Elevated Railroad eight 600-hp. boilers were installed to one 15,000-kw. turbine, or 3.2 kw. per boiler horsepower. One additional turbine of 15,000 kw. has been installed since the station was built, and four boilers will be added to the boiler plant, which will make the ratio of actual installed capacity about 3¾ kw. to the boiler horsepower.

At the No. 1 Waterside Station of the New York Edison Co. there are 56 boilers of 650 rated hp. each, making a total of 36,400 b.hp. for an installed generator capacity of 120,000 kw., or 3.3 kw. per b.hp.

At Waterside No. 2 Station there were installed 96 boilers of 650-hp. capacity each, making a total of 62,400 b.hp., for a generator capacity of 93,000 kw., giving a ratio of about 1.50. Since the use of underfeed stokers with forced draft, 36 of these boilers are kept regularly out of service, the ratio of those in actual use to the installed generator capacity being 4.2.*

ARCHITECTURAL EFFECT

Many of the early plants were built without any pretension to architectural effect, but an important public utility building is now expected by the public to be more than utilitarian in appearance. The central power station nowadays is as much of a public institution as a post office, a library, a bridge, a city hall or a national monument, and numerous examples of modern central-station architecture were thrown upon the screen to show how dignity, power and beauty can find expression in central-station architecture.

BOILERS

The water-tube boiler of the Babcock & Wilcox type with superheater is practically the standard for large power construction all over the country. A modification of the Stirling type has lent itself to the construction of the largest unit yet built, 2365 hp., which takes about one-half the cubic space and about one-fourth the floor space per horsepower of the boiler of the usual type. Most of the water-tube boilers for central-station service are built in sizes of from 500 to 650 hp.

Central-station engineers do not yet seem quite ready to adopt units of larger size, chiefly because a larger proportion of boiler capacity will be thrown out of service by a trouble which involves the shutting off of a single boiler. Another reason for keeping to the present standard sizes is the experience obtained during the past few years in running boilers from 200 to 300 per cent. of their rating on the peak loads. Generally speaking, the peaks are of short duration, from one-half hour to two hours, and the efficiency at the greater rating is so little lower for this short period that both the interest on the lower first cost and the saving by banking fewer fires overbalance the small loss in efficiency at the peaks.

PRESSURES AND SUPERHEAT

Station pressures are slowly rising, being frequently 175 to 200 lb., and in the Northwest Station the pressure is 250 lb. Superheat varies from 100 to 200 deg. F., usually the former, and is commonly produced in a superheater located in the boiler itself over the second pass. Boilers usually have the ordinary brick setting. Some engineers have tried inclosing the brick setting in a steel casing, as, for example, at the St. Louis plant. This is done in order to increase boiler efficiency by preventing infiltration of air through the brick work, but results have not yet been convincing enough to spread the practice widely.

MECHANICAL STOKERS

Automatic stokers have been for many years considered a necessary part of central-station equipment, and all the largest stations have them. There are three general types; the chain grate, the overfed inclined grate, and the underfed type. In the Middle West, where much low-grade coal is used, the chain grate, with a long reverberatory arch over it, has proved successful. Chain grates are being tried out in the Northwest Station with two different kinds of baffling. In the East, the other types of stoker are generally preferred, especially where coking coals are used.

FURNACES

During recent years, the municipalities have been enforcing more strictly their regulations about the emission of smoke from chimneys, and it has become necessary for central-station engineers to plan their boiler and furnace installations with a view to smoke prevention. It is now a well recognized fact that combustion can be complete only when the combustion chamber is of sufficient size to permit the combustible matter in the coal to be thoroughly combined with oxygen before the gases are cooled by the boiler tubes. Unless the volatile hydrocarbons can be burned by being forced through the fire, as is the case with the underfeed stoker, furnaces of the Dutch-oven type, or with large combustion chambers are a necessity for the usual type of boiler. [The back ends of the boilers at the Boston Elevated Station are set 8 ft. above the grate, and those at the 201st St., New York, Station, 10 feet.—Editor.]

ECONOMIZERS

The net result of using an economizer is usually not large enough to justify the economizer unless the load factor approaches that of a manufacturing plant, or unless coal is dear, or there is some special reason for needing the storage of a large quantity of hot water to help out the boiler plant.

The extension of the Fisk Street Station, in Chicago, is being fitted with an economizer installation, but on a plan different from that usually followed in past installations, in that there is to be a separate economizer for each battery of

*At the 201st St. station of the United Electric Light & Power Co., 36 650-hp. boilers are expected to care for 110,000 kw., giving 4.7 kw. per b.hp. At the Delray station of the Detroit Edison Co., twelve 2365-hp. boilers will serve six 20,000-kw. turbines, giving 4.22 kw. per b.hp. The stacks and breechings have been so proportioned that in emergencies three boilers may furnish two turbines, giving 5.65 kw. per b.hp.—Editor.

boilers, each with its own induced draft fans. In very large stations provision has to be made for the proper admission of the air to the boiler room for combustion, particularly where natural draft is used. The required quantity is so enormous that in order to make the boiler room habitable in winter time it is desirable to handle the air necessary for combustion through the ashpit, and not through the firing aisle.

STEAM TURBINES

Passing to the generator end of the subject the lecturer showed a slide of the first Westinghouse turbine installed in a central station, that of the Hartford Electric Light Co. in 1901, and of the first 5000 kw. turbine put in by the General Electric Co. at the Fisk Street Station, which was one of the first of its large machines to go into commercial service. After a few years' experience with sizes of 5000 kw. and under, turbine manufacturers began to increase to 7500, 10,000, 15,000, 20,000, and have recently designed a turbine of a capacity as high as 35,000 kw. in a single unit. This increase in capacity has been accompanied by increase in the turbine speed, which has enabled modern machines of very large capacity to be built, but little if any larger in overall dimensions than some of the earlier machines of a much smaller output. At the St. Louis Station the ratio of space occupied per kilowatt is about one to ten in favor of the turbine, as compared to their original engine installation. The 7500-hp. reciprocating engine unit built for New York occupied about four times as much floor space as the equivalent steam turbines and generators which came along later. Nowadays the ratio would be even greater. A 30,000-kw. unit has been designed by the Westinghouse Co. to be installed by the Interborough Rapid Transit Co. in its Seventy-fourth Street Station in New York City. This is being built in two units, the high-pressure to run at 1500 and the low-pressure at 750 revolutions per minute. With 200 lb. steam pressure, 125 deg. superheat and 29 in. of vacuum, a steam guarantee of 11.27 lb. per kilowatt-hour at 30,000 kw. output was given. The Rankine cycle efficiency of the combined units is guaranteed to be 75 per cent. which is said to be higher than for any machine yet designed. This is particularly significant with the vacuum specified.

CONDENSERS

The question of condenser-tube corrosion seems to have narrowed down to a search for an alloy of high heat conductivity, which is not deteriorated by the treatment that it receives during manufacture, and is not subject to local galvanic action between particles of the different metals in its composition; nor by the presence of impurities in the condensing water.

The cooling surface in the condenser of the 25,000-kw. Parsons turbine in Chicago is a little less than 40,000 sq.ft., or 1.6 sq.ft. of condensing surface per kilowatt. This is about 40 per cent. of the cooling surface thought necessary ten years ago.*

AUXILIARIES

Generally speaking, in large stations steam auxiliaries are used, and the exhaust is passed into the feed-water heater. It may be sufficient to heat the feed water to 200 deg., but in very large modern stations the auxiliary steam exhaust is usually sufficient only during times of light load, requiring an extra supply of steam from other sources during the times of heavy load, when the auxiliary exhaust is not increased in proportion.

One method of supplementing the feed-water heaters at peak loads is by bleeding steam from one of the intermediate stages of the main turbine unit.

Pumps and other auxiliaries that can be designed to run at high speed are now nearly always driven directly by turbines, and even low-speed apparatus can now be geared to them. At the new 201st St. station in New York, there are 15 small turbines driving the auxiliaries for three 15,000-kw. main units. Turbine drives are now largely used for boiler-feed and for hot-water pumps.

PIPING

The addition of superheat to high-pressure steam has required the substitution of cast steel for cast iron fittings and valves in the main steam line. The early plants where superheat was first installed had to learn this by hard experience, and many rebuilt their pipe lines within a few years of their installation. The valve seats and stems are now usually made of nickel steel, nickel bronze, or Monel metal.

A matter that has received attention in some large stations, and will doubtless receive careful study in all of them, is the installation of permanent apparatus for weighing or measuring water used by turbines, and taking temperatures of steam and water wherever these weights and temperatures can be of use, both in keeping the operating force informed on the day to day or even hour to hour economy in the station, and in making occasional performance tests.

THE BOILER ROOM

The attention of engineers is being directed more and more to securing better economy in the boiler room. This is the point in the station where intelligence in watching and following conditions of boiler operation will instantly result in appreciable fuel economy. For years the electrical end of every station has been completely equipped with accurate and expensive indicating and recording instruments, but it has only recently become the practice to install instruments in the boiler room.

It has been proved by actual experience in Detroit that if men who rank as skilled mechanics are employed as firemen they can be trained to become combustion experts, through their ability to follow the indications of steam-flow meters, draft gages, CO_2 recorders, and similar instruments.

When it is considered that about 60 to 70 per cent. of the cost of central-station operation is fuel cost, the importance of raising the standard of the boiler-room personnel is self-evident.

Recently visual load indicators have been mounted in the fire room to warn the firemen of changes in load. The next instrument to be exploited was the CO_2 recorder. Being a delicate instrument, and one whose operation is not easily understood by the class of help commonly employed in fire rooms, it has to be handled with great care, and has not given universal satisfaction. It is now well recognized that a high CO_2 content of flue gas alone is not the best all-round test for efficient boiler operation, as the samples of the gas may vary widely from different points in the flue.

One of the most satisfactory instruments yet devised for keeping track of steam-boiler performance seems to be the steam flow meter, which, mounted in plain sight on the boiler front, tells the fireman just how many pounds of steam his boiler is evaporating at any instant, and enables him to regulate the fires accordingly.

The automatic regulation of the draft here referred to is not the common damper regulator which is controlled by the steam pressure, but a simple little device mounted alongside the furnace wall consisting of a diaphragm which is actuated by the pressure or vacuum existing in the furnace, the idea being to keep the furnace conditions constant for a predetermined load. This device is useful where forced draft is used, in which case the draft regulator controls the fans or machinery for producing the forced draft, and not the damper in the flue. Drawing a parallel with the electrical instrument, the draft regulator just described corresponds to the voltage regulator on the electrical system, and the steam flow meter to the ammeter.

DRAFT APPARATUS

In the past engineers have felt that the natural draft incidental to the chimneys necessary to carry off the products of combustion was sufficient for the operation of the furnace. At present, however, the need of a more positive control over the draft, and of securing high draft pressure almost instantly to meet some sudden demand, is leading to the general introduction of forced-draft apparatus.

The ideal arrangement seems to be an automatic stoker, which normally runs on natural draft, with some cheap apparatus for materially increasing this draft by putting pressure under the grate to meet heavy peak loads and unexpected demands. Such is the arrangement at the L Street Station, Boston, where, by means of steam jets, boilers are operated for peak work at 300 per cent. of rating.

FEED WATER

In very large stations care is now being taken to keep the feed water pure, not only with respect to solid matter, but also to the alkalies in solution. With the present tendency to force boilers it becomes more necessary to remove the scale-forming ingredients. A bit of scale dropped in a tube where it is exposed to flame, will cause a bulge or rupture in a short time. The purer the water the less frequently will boilers have to be blown down, and the less make-up water will be required.

With feed water that does not require filtration the open type of heater is useful as a purifier, and is for this reason widely used in the Middle West.

Even in a surface condensing plant where the amount of make-up water from outside is a minimum, the open heater is more economical than a closed heater, because all of the heat units in the auxiliary exhaust are utilized by its direct mixture with the steam.

*A condenser with 25,000 sq.ft. cooling surface will care for a 22,000-kw. turbine in Waterside No. 2. This is less than 1.14 sq.ft. per kw.—Editor.

Half-Million-Dollar Experiment Station

Plans for the proposed $500,000 experiment station of the U. S. Bureau of Mines, to be located in Pittsburgh, Penn., have been approved by the commission appointed by Congress for that purpose. The Federal Government now owns the property upon which will be erected a group of buildings, especially designed and adapted for the carrying on of the mine-safety work and other investigations in which the Bureau of Mines is interested.

Congress, a year ago, authorized a new home for the Bureau of Mines, to cost $500,000. It is now expected that Congress, in its present session, will make a specific appropriation so that construction work may begin. It is hoped that contracts may be let by July 1.

The proposed site consists of nearly 12 acres of land, part of it on the higher level of the city streets and part of it on the level of the Baltimore & Ohio R.R., which will furnish adequate facilities for passengers and freight traffic.

The group consists of the three main buildings. The central building of the group, the mining building, will be three stories in height, flanked by the mechanical, and the chemical buildings. In the rear of these, and inclosing a court, will be the service building. Beyond the service building, and spanning what is known as Panther Hollow, thereby connecting the Bureau of Mines buildings with the Carnegie schools, will be two buildings, over the roofs of which will pass the roadway from Forbes St. to the Carnegie schools and Schenley Park.

The portion of Panther Hollow above the power buildings will be arranged as a miners' field, the slopes of the ravine being utilized as an amphitheater, which will accommodate 20,000 spectators.

The main, or mining, building will contain the administrative offices, and those of the mining force. In it will be an assembly and lecture hall, a library, smoking room and other rooms for demonstrations and training in mine rescue and first-aid. The mechanical building will be for experiments and tests of mining machinery and appliances; and the chemical building for investigation and analyses of fuels, explosives and mineral substances.

The buildings now used by the Bureau of Mines as an experiment station, at Pittsburgh, were loaned by the War Department, as an emergency measure, when the bureau was created.

Dr. Sheldon's 25th Anniversary

On Saturday evening, Mar. 21, at the Hotel Astor, New York City, Manhattan, a dinner was tendered Dr. Samuel Sheldon in honor of his 25 years of service as professor of physics and electrical engineering in the Polytechnic Institute, Brooklyn. About 150 guests were present, including students and alumni of the Polytechnic and men prominent in engineering circles of today.

Thomas Commerford Martin, ex-president of the American Institute of Electrical Engineers, acted as toastmaster. Dr. Fred. W. Atkinson, president of the college, spoke on the life of Dr. Sheldon and his studies abroad. Samuel Owen Edmonds, a patent lawyer of note, told of Dr. Sheldon's work as an expert in several large patent cases. Several interesting reminiscences of the Polytechnic in 1890 were given by William Lord Bliss, the oldest student in the first class of electrical engineering which Dr. Sheldon taught at the Polytechnic. Ralph Wainwright Pope, honorary secretary of the American Institute of Electrical Engineers, spoke reminiscently of many interesting matters, and mentioned Dr. Sheldon's success as president of that organization.

In reply to these addresses, Dr. Sheldon expressed his deep appreciation of the kind thought and feeling which had led to the testimonial banquet. He sketched his experienced career prior to accepting the call to the institute, 25 years ago, and then spoke of the growth of the Polytechnic until today it stands as one of the foremost schools of its kind in the country.

"When I joined the faculty," said Dr. Sheldon, "plans for the new institute building were being made, and courses leading to the degrees of civil and electrical engineers had been determined upon. I was asked to take charge of the development of the latter course in addition to directing the work in the department of physics. Outside of a few civil engineering instruments and some apparatus for the experimental illustration of lectures, there was no laboratory equipment. The problem which the faculty undertook to solve at that time, and which is even yet under consideration, was the elevation of scholastic standards, without the cessation of student attendance and without the expenditure of large sums of money for the purchase of adequate equipment."

The affair as a whole was a splendid tribute to a splendid man. Student cheers and songs under the leadership of Harry Young, '14, added to the general enthusiasm. It was a time of good will and kindly feeling.

National Heating Convention

The sixth annual convention of the National District Heating Association will be held in Rochester, N. Y., May 26, 27, 28 and 29, 1914. The program is substantially as follows:

TUESDAY, MAY 26, 2 P.M.

Welcome address, by the Mayor of Rochester; response; president's address; report of secretary-treasurer; appointment of nominating committee; report of underground construction committee, E. Darrow, Indianapolis, Ind., chairman.

Entertainment: For the ladies, auto ride, leaving Seneca Hotel at 3 p.m., and returning at 5:30 p.m.

TUESDAY, MAY 26, 8 P.M.

Report of the nominating committee. Address—R. M. Searle, vice-president, Rochester Ry. & Light Co. Subject, "Public Policy of Utilities." Address, "Manufacture of Welded Iron and Steel Pipe," accompanied by moving pictures showing the progress of manufacture.

At the evening session the ladies will be invited to attend as the addresses will be interesting to all.

WEDNESDAY, MAY 27, 9:30 A.M.

Report of the meter committee, A. D. Spencer, Detroit, Mich., chairman. "Use of Bleeder Turbines in connection with Steam Heating," by R. D. De Wolf, Rochester, N. Y. Election of officers. Report of record committee, A. P. Biggs, Detroit, Mich., chairman.

WEDNESDAY, MAY 27, 2 P.M.

Discussion session. Subjects to be discussed as follows: "Hot-Water Heating under Forced Circulation." "Expense of Operating Centrifugal Pumps vs. Double-Acting Pumps." "Some Effects of Utility Regulation as Affecting District Heating." "Effect of Superheated Steam on Heating Systems." District Heating for Small Towns and Cities of 10,000 Population and Under." "Heat losses from Buildings of Latest Construction." "Which Is More Profitable, to Shut Off Steam at Night or Keep It On Continuously?" "Economic Advantages to Consumers of Central-Station Heating Service Over Individual Heating Plants."

Entertainment for Wednesday: For the ladies, Wednesday morning, shopping tours; Wednesday afternoon, trip on Lake Ontario, returning at 6 p.m. Wednesday evening, theater party for all.

THURSDAY, MAY 28, 9:30 A.M.

Report of rate committee, E. L. Wilder, Rochester, N. Y., chairman. "Customers' Steam-Heating Systems," H. R. Wetherell, Peoria, Ill.

THURSDAY, MAY 28, 2 P.M.

"Commercial Steam Heating in New York City," George W. Martin, general manager, New York Service Co. Report of educational committee, D. S. Boyden, Boston, Mass., chairman. Report of station-operating committee, B. T. Gifford, Grand Rapids, Mich., chairman.

Entertainment for Thursday: For the ladies, Thursday morning, 10:30, card party at Seneca Hotel. Afternoon, auto ride, with tea at Oak Hill Country Club. Evening, for all, informal dance at Seneca Hotel, 8:30 to 11 p.m. For the men, Thursday, 4 p.m., visit to the Taylor Instrument Factory.

FRIDAY, MAY 29

The entire convention as the guest of the American District Steam Co. will go to Niagara Falls on a special Pullman train, via New York Central Lines, stopping en route at Lockport, where the first district heating plant was installed, taking luncheon at the works of the company at North Tonawanda, and spending the afternoon sight-seeing at Niagara Falls, followed by dinner at the Clifton Hotel on the Canadian side, and returning to Rochester in the evening.

The program as outlined is good, and assurances already received indicate that the sixth convention will be the largest attended yet. The entertainment committee has a large fund at its disposal. A cordial invitation has been extended to those district heating stations that are not now members to join the association either at the convention or in advance. There will be a complete exhibit in connection with the convention and applications for space should be made directly to Secretary D. L. Gaskill.

The Seneca Hotel at Rochester will be the headquarters of the association and reservations for rooms should be made directly with the hotel management.

Threaten Rate Reduction at Cleveland

A mandatory ordinance now pending before the city council of Cleveland, Ohio, will, if passed, reduce the Cleveland Electric Illuminating Co.'s maximum rate to residence customers to 3c. per kw.-hr. The ordinance has passed its first reading.

Residence customers are now served under a sliding scale of prices, the maximum being 10c. per kw.-hr. and the average rate earned under this schedule being 6.25c. per kw.-hr. The average lighting bill in Cleveland homes is $1.91 a month. At present the company has no established minimum bill. The general impression seems to prevail among the company's staff that the rate is confiscatory and will not be sanctioned by the Public Service Commission.

Old Pumping Station May Be Abandoned

Commissioner Ingersoll, of the Brooklyn Park Department, announces that the pumping station at the foot of Lookout Mountain, Prospect Park, which for many years has supplied the park lakes with water, may soon be closed. William T. Travers, the engineer, recently resigned after 44 years of service. There has been no one appointed to succeed him. The firemen were assigned to other duties in the department.

That the machinery is in need of repairs and new machinery would cost about $7000, is one of the reasons for closing the station.

The artesian well in the pumping station which is considered one of the landmarks of Prospect Park, was sunk by C. C. Martin, the engineer who had charge of the building of the Brooklyn Bridge. The well is 50 ft. in diameter and 50 ft. deep. An iron stairway leads down to its surface, and there are hundreds of callers daily to inspect it. The work of sinking the well was difficult from an engineering standpoint because it had to be built with a coffer-dam.

Since the temporary shutting down of work at the pumping station, the water for the park lakes is being taken from the city reservoirs. The Catskill aqueduct will soon bring an enormous quantity of water to the city, and for that reason the Prospect Park well may never be needed.

BOOKS RECEIVED

ELEMENTAL MAGNETISM AND ELECTRICITY. By C. M. Jansky. McGraw-Hill Book Co., New York. Cloth; 212 pages, 6x9¼ in.; 121 illustrations. Price, $1.50.

APPLICATION OF POWER TO ROAD TRANSPORT. By H. E. Wimperis. D. Van Nostrand Co., New York. Cloth; 125 pages, 4¾x7¼ in.; illustrations; tables. Price, $1.50.

FUEL. By J. S. S. Brame. Longmans, Green & Co., New York. Cloth; 372 pages, 5½x9 in.; 73 illustrations; tables. Price, $3.50.

The Supplymen's Association of the American Boiler Manufacturers' Association announces the completion of its list of boiler, tank and stack manufacturers of the United States and Canada. It is compiled in neat booklet form and contains the names and the addresses of over 900 manufacturers. These books are offered to interested parties, such as tool and material manufacturers for the sum of $3 per copy. Address F. B. Slocum, Secretary, The Continental Iron Works, West & Calyer Sts., Brooklyn, N. Y.

Tramway Construction and Material—Proposals are requested by the Direccion General de Obras Publicas, Ministerio de Fomento, Madrid, Spain, for the concession and construction of an electric tramway in Madrid. The American consul at Madrid states that the estimated cost of this tramway is $22,935, and its rolling stock must include at least two electric cars. Work must be commenced within one month from the date of award and finished within three months from the same date. Proposals should be submitted through a resident agent before Apr. 22. A list of such agents can be obtained from the Bureau of Foreign and Domestic Commerce, Washington, D. C..

Large Funnels—The last of the four funnels of the new Cunard liner "Aquitania," the largest British steamship, was placed in position in Clydebank dock. The funnel was lifted into place by a 150-ton crane. The width of the funnel fore and aft is 24 ft., and extends above the keel 161 ft. Each one with its section of uptakes and boilers weighs 1500 tons.—"Practical Engineer," London.

Recent Court Decisions

Digested by A. L. H. STREET

Minnesota Boiler-Safety Law—Mar. 3 a jury sitting in St. Paul exonerated the St. Paul Boiler Manufacturing Co. of a charge of having delivered a defectively constructed boiler to a customer. Section 4746 of the Minnesota Statutes, 1913, reads: "Every person who shall construct a boiler or steam pipe of iron or steel plates known to be faulty or imperfect, or shall drift any rivet hole to make it come fair, or who shall deliver any such boiler for use, knowing it to be imperfect in its flues, flanging, riveting, bracing, or in any of its other parts, shall be guilty of a gross misdemeanor, and punished by a fine of $200, one-half of which shall be paid to the informer." A prosecution was instituted against the boiler company under this law, it being alleged in the indictment that the company delivered to one Chas. J. Gustafson a high-pressure boiler, which was faulty and imperfect in its riveting, bracing, and the insertion of gage cocks. It was specifically charged that rivet holes near the firebox door were drifted to make them come fair; that there were no braces from the boiler head and rivets were placed to simulate such braces; and that the lower and middle gage cocks were improperly inserted below the crown sheet. After a vigorous trial of the case for two days, the jury returned an immediate verdict in the company's favor, thus finding that the company established its claim that the boiler was properly constructed and conformed to the warranty under which it was sold that it was adapted to a working pressure of 100 lb.

Legal Status of Public Service Franchises—Suit may be maintained in the name of the state to forfeit a public service corporation's franchise granted by a city, since, in granting franchises, municipalities act as agents of the state. The city is entitled to sue to annul a franchise for breach of its contractual provisions; but the state is the proper party to sue for abuse of the franchise. "It is implied, as the essential condition upon which corporate life and powers are granted to public service corporations, that they shall fairly and substantially perform the functions and discharge the duties for which they have been created. A willful and persistent failure to do so may subject their franchises to forfeiture and themselves to dissolution."

This implied duty is violated by unreasonable discrimination in service or charges to consumers, or by illegal combination with other public service companies. Although refusal of service in particular instances will not ordinarily furnish ground for forfeiting a franchise, they may be considered with other breaches of duty, in determining whether there has been such abuse of the franchise as warrants a forfeiture. (Alabama Supreme Court, State vs. Birmingham Water Company, 64 "Southern Reporter" 23.)

ENGINEERING AFFAIRS

The trustees of Columbia University will raise the requirements of admission to the schools of mines, engineering and chemistry. After July 1, candidates will be required to present evidence of such preliminary general education as can be had by at least three years' study in a college or scientific school of high rank. Candidates for degrees will be admitted to the second year of the present course upon showing evidence that they have completed the work of the present first year in addition to the existing entrance requirements.

The New England Association of Commercial Engineers gave its annual dinner at the Revere House, Boston, on Saturday evening, Mar. 21. About 150 members and guests were present. Mayor James W. H. Myrick acted as toastmaster. The speakers were District-Attorney Joseph C. Pellitier, of Suffolk County, and the Hon. William S. McNary, ex-member of Congress and chairman of the Harbor and Land Commission. John A. Hill, of the Hill Publishing Co., and Jack Armour, of "Power," New York, were also among the guests. A very enjoyable cabaret show was given, and the meeting ended with a stage performance.

Oil-Burning Locomotives in India—The Northwestern Railway, of India, has recently built its first locomotive fitted to burn oil as fuel.

PERSONALS

William T. Travers, for 44 years engineer at the Prospect Park pumping station, Brooklyn, N. Y., has resigned. A brief account is given of this old pumping station on another page.

Fred B. Smith has been appointed assistant to President T. F. Manville of the H. W. Johns-Manville Co., New York City.

Walter C. Allen, for the past five years general manager of the Yale & Towne Manufacturing Co., was elected a vice-president of that company, following the annual meeting of the stockholders on Mar. 12.

OBITUARY

EDWIN M. CORYELL

Edwin M. Coryell, consulting engineer, New York City, died from heart disease in his office at 11 Broadway, Mar. 23. He was in his 66th year and had been for many years consulting engineer for the Cameron Steam Pump Works of New York City.

JAMES W. THOMSON

James W. Thomson, chief engineer, U. S. N., retired, died at his home in Moorestown, N. J., Mar. 17. He was born in Wilmington, Del., Nov. 10, 1836. He was appointed third assistant engineer in the United States Navy in 1856, and was promoted until he was chief engineer in 1862. He was retired in 1896 with the rank of rear-admiral.

WALTER LAIDLAW

On Wednesday, Mar. 25, Walter Laidlaw, secretary of the International Steam Pump Co., New York City, died of heart disease while on the way to his office.

Every engineer who had the privilege of personal contact with Mr. Laidlaw honored his unswerving integrity, loyalty and fairness, and respected the ready application of his vast experience and his clear, commonsense consideration of practical engineering and manufacturing problems. Very few, however, knew of his unusually interesting earlier experience and his highly privileged personal associations.

Mr. Laidlaw was born in Scotland in 1849. In his youth he served an apprenticeship of 4½ years as machinist with James Sheil, maker of machinery for the manufacture of Scotch-Tweed, engines, waterwheels, shafting and gearing. This course was supplemented by 1½ years' service as an "imperial erector" with Caird & Co., shipbuilders and engineers, Greenoch, Scotland, where he was engaged in the erection of first-class ocean steamships. He endured the usual hardships and privations of the apprentices of his class at that time, but his interest and ambition were such that in spite of the hard and continuous labor, he heartily enjoyed the service and his opportunity for acquiring knowledge and experience.

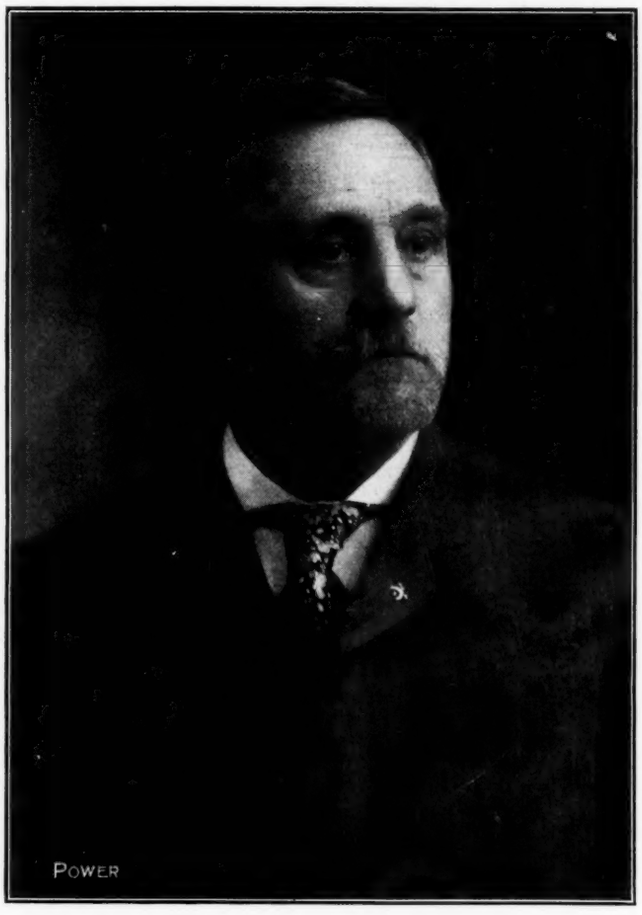
He next entered the engineering department of Trinity House, which body has official charge of the lighthouses of Great Britain. He served as engineer and chief engineer for 10 years and worked in this most interesting period of lighthouse development shoulder to shoulder first with Prof. Michael Faraday, and later with his successor, Prof. Tyndall; he also enjoyed the acquaintance and at times coöperation of Lord Kelvin in some of these developments.

Mr. Laidlaw was actively engaged in the design, equipment and erection of some of the most famous British lighthouses. While in this service he drew the specifications for and purchased the first direct-acting generator ever used for lighting, which he installed and for a while operated in the lighthouse at the Lizards, where it is still in satisfactory operation as an auxiliary.

In 1891 he came to the United States and went to Cincinnati, working for a while as draftsman for the Lane & Bodley Co. and then as constructing engineer for Procter & Gamble, Ivorydale, Ohio.

In 1909, he became vice-president and manager of the works of the Laidlaw-Dunn Co., afterward the Laidlaw-Dunn-Gordon Co. During this period Mr. Laidlaw realized the full development of his engineering abilities and became greatly interested in the technical education and advancement of young men, as will clearly be attested by a host of prominent engineers in the Central West. It was largely through his efforts that the Ohio Mechanics Institute was placed upon a solid basis and began its successful expansion. He served at one time as president of the institute and recently stated that one of the most pleasant memories of his life was the privilege of awarding the diplomas to the young graduates in whom he had taken so much interest. Mr. Laidlaw remained a life member of the corporation.

In 1905 he was elected a member of the American Society of Mechanical Engineers. In 1910 he became general manager of the Snow Steam Pump Works at Buffalo, and in 1911 a member of the executive committee of the International Steam Pump Co., for which position his training had eminently fitted him. In 1914 he became its secretary.



WALTER LAIDLAW

Mr. Laidlaw's death was a great shock to his immediate associates and the engineering profession. His modesty prevented reference by him to his earlier experiences and associations, and it is believed this short sketch will be of interest to those engineers who had not previous knowledge of them.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

of Power, published weekly at New York, N. Y., required by the Act of August 24, 1912.

Editor, Fred R. Low, New York, N. Y.
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Emma B. Hill, 80 Munn Ave., E. Orange, N. J.

The balance of the stock issued (less than 1% each) is owned by 69 employees, 3 ex-employees, and 14 others who are wives, daughters or relatives of employees.

Known bondholders, mortgagees, and other security holders holding 1 per cent. or more of total amount of bonds, mortgages or other securities. Mortgage on building held by Dime Savings Bank, Brooklyn, N. Y.

C. W. Dibble, Vice-President,
HILL PUBLISHING COMPANY.

Sworn to and subscribed before me this 24th day of March, 1914.

RICHARD L. MURPHY,
Notary Public.
(My commission expires March 30, 1915)